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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Initial issue in Facility Eng Manual.	Doug Volkman, *PM-2*	Dennis McLain, *FWO-FE*
1	2/9/04	Incorporated IBC & ASCE 7 in place of UBC 97; incorporated DOE-STD-1020-2002 versus 1994; incorporated concepts from DOE O 420.1A. FEM became ESM, an OST. General revision and improvements.	Mike Salmon, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
2	5/17/06	General revision and improvements; OST became ISD.	Mike Salmon, *D-5*	Mitch Harris, *ENG-DO*
3	10/27/06	Administrative changes only. Organization and contract reference updates from LANS transition; 420.1A became 420.1B; deleted NM Bldg Code based on 9/18/06 variance. Clarified table. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates. Other administrative changes.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
4	6/19/07	Added risk evaluation for projects underway due to increased seismic design basis from 2007 PSHA update (Applicability sections 1.3.B and C).	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
5	11/19/08	Incorporated IBC 2006 & ASCE 7 2005 in place of IBC 2003 & ASCE 7 2002. General revision and improvements.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
6	6/20/11	Added requirements for Designated Seismic Systems, App A on anchorage, updates for consistency with Section III, updated references.	Mike Salmon, *D-5*	Larry Goen, *CENG*

Contact the Structural Standards POC
for upkeep, interpretation, and variance issues

Ch. 5, Section I	**Structural POC/Committee**

This Chapter is online at http://engstandards.lanl.gov

I GENERAL CRITERIA FOR ALL LANL STRUCTURES

1.0 USE OF THIS CHAPTER

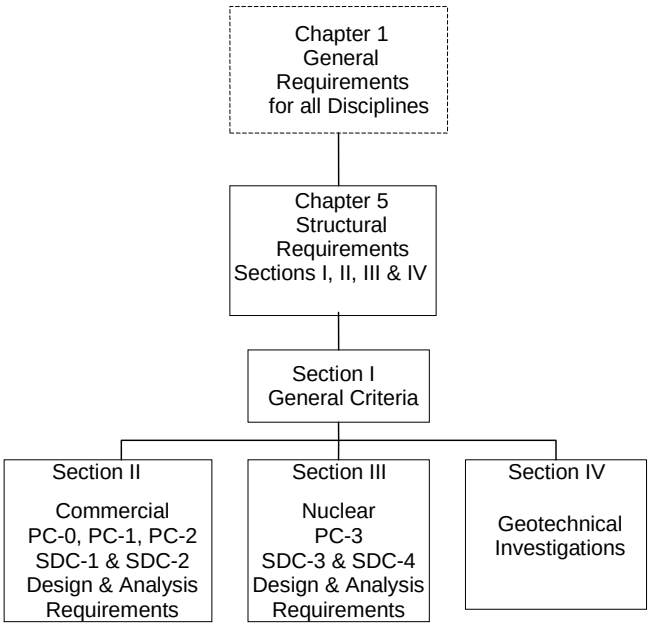
1.1 Purpose

A. This Chapter of the Los Alamos National Laboratory (LANL) Engineering Standards Manual (ESM) presents structural design criteria that are unique to LANL. The criteria presented herein are in addition to nationally accepted design criteria for structures. In general, the more restrictive provisions of the International Building Code (version and amendments per ESM Ch 16, IBC Program) and the New Mexico Commercial Building Code (NMAC 14.7.2) shall be the code of record for the design of structures, systems, and components (SSC) at LANL.

B. The edition of the code of record shall be established in project documents for major capital project, or shall be clearly documented in project records for other projects (e.g., DCP, minor modifications, etc). In addition, these criteria implement the Natural Phenomena Hazards (NPHs) mitigation requirements in Department of Energy (DOE) Order 420.1B, *Facility Safety*, that are applicable to all DOE nuclear and non-nuclear facilities.

C. This Chapter presents the requirements of the DOE Orders and implementing standards specific to LANL so that design engineers not familiar with DOE requirements may utilize this as a source document without referring to the parent Orders, Standards, and Guidance documents. This Chapter provides overall requirements and guidance for developing structural designs. The design organization is responsible for providing the complete design package including drawings, specifications, a design basis document, and other documentation as described in this Chapter. Goals for design basis documentation include:

- Achieve uniformity in documentation for LANL structure designs.
- Provide assurance that LANL-specific loads are addressed.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D. *Guidance: This Chapter also implements the DOE and LANL policy of a graded approach applied to structural design. Per LANL requirements (AP-341-502[1]), facility work is subjected to a level of management control commensurate with the importance of the work to safety, environmental compliance, safeguards and security, programmatic importance, magnitude of hazard, and financial impact.*

At LANL, the graded approach is implemented by Management Levels (ML). The greatest level of management control and rigor is exercised for ML-1 with the least level for ML-4. From a structural design standpoint with respect to safety, ML-1 SSC are normally those designated as safety class for Hazard Category (HC) 2 and 3 nuclear facilities or serve to provide protection to the public for non-nuclear facilities. ML-2 SSC are those designated as safety significant for HC 2 and 3 nuclear facilities or provide worker protection or significant protection against the uncontrolled release of hazardous materials from non-nuclear facilities. ML-3 SSC are important to safety or other matters but their failure would have only minimal off-site impact. ML-4 SSC failure is analogous to commonly accepted industrial risk.

DOE requirements and guidance for implementation of a graded approach are implemented in design for NPH through the designation of Performance Categories (PCs) as defined in DOE O 420.1B, DOE G 420.1-2, DOE-STD-1021, and DOE-STD-1020 are discussed in the following section. This Chapter utilizes the NPH PCs for assigning the appropriate structural design requirements. LANL ML designations and requirements must also be included for structure design projects.

Per ESM Chapter 12 Nuclear, new nuclear facilities and major modifications to same[2] require compliance with DOE-STD-1189, Integration of Safety into the Design Process. Appendix A of DOE-STD-1189 provides the requirements for seismic design of safety SSCs as related to radiological hazards. Therefore, in addition, Chapter 5 provides requirements for Seismic Design Categories (SDCs) for safety SSCs related to radiological hazards.

NOTE: These 1189-based Seismic Design Categories (SDCs) are not to be confused with use of the SDC acronym by the IBC.

1.2 DOE Natural Phenomena Hazard Mitigation Requirements

A. *Guidance: NPH mitigation objectives defined in Chapter IV of DOE O 420.1B are to ensure that DOE facilities are designed, constructed, and operated so that the general public, workers, and the environment are protected from the impact of NPHs. The provisions in the Order apply to DOE sites and facilities and cover all NPHs such as seismic, wind, flood, and lightning. Where no specific requirements are specified, model building codes or national consensus industry standards shall be used.*

B. SSC shall be designed, constructed, and operated to withstand the effects of NPH as necessary to ensure the confinement of hazardous material, the operation of essential facilities, the protection of government property, and the protection of life safety for occupants of DOE buildings.[3] The design process shall consider potential damage and failure of SSC due to both direct and indirect natural phenomena effects, including common cause effects and interactions from failures of other SSC.

[1] LANL AP-341-502, R1, Management Level Determination
[2] See ESM Chapter 1 Section Z10 for definition of major mod
[3] NPH mitigation design requirements are presented in Ch IV of DOE 420.1B.

C. SSC for new DOE facilities, and additions or major modifications to existing systems, structures, and components shall be designed, constructed, and operated to meet the requirements in the previous paragraph. Any addition and modifications to existing DOE facilities shall not degrade the performance of existing systems, structures, and components to the extent that the objectives in this Section cannot be achieved under the effects of natural phenomena.

D. *Guidance: DOE G 420.1-2 notes that a key element of DOE NPH mitigation requirements is the use of a graded approach. DOE facilities are diverse enough to warrant a graded approach (e.g., some are office buildings while others contain substantial inventories of hazardous material). Such an approach recognizes the diversity of objectives for NPH protection, the diversity of facilities, and the diversity of measures that are appropriate to ensure suitable NPH protection. When properly developed and implemented, a graded approach optimizes the allocation of effort and resources.*

E. The graded approach is implemented by assigning SSC to PCs depending on facility characteristics and defining several sets of NPH design/evaluation provisions with increasing conservatism (i.e., producing a decrease in probability of damage or failure to perform the intended safety function). Five PCs are defined in DOE G 420.1-2 ranging from PC-0 through PC-4. PC-0, PC-1, and PC-2 NPH requirements are similar to those of the IBC, and PC-3 and PC-4 NPH requirements approach those for commercial nuclear power plants.[4]

F. *Guidance: Specific design criteria for DOE facilities for each PC are provided in DOE-STD-1020. These criteria are adopted for design of LANL facilities in this Chapter.*

1.3 Applicability

A. The requirements of this Chapter shall be applied to the design of new facility and programmatic SSC. In addition to new structural designs, this Chapter applies to renovation, replacement, modification, maintenance, or rehabilitation projects. Applicability of the provisions of this Chapter is illustrated in Table I - 1.

Table I - 1 Applicability of LANL ESM Chapter 5 to Structural Design

Circumstance	Is ESM Chapter 5 Applicable?
New structures, including replacement of existing facilities, and new SSCs that are PC-0 (e.g., sheds, sidewalks)	Yes
New non-structural systems & components in new and existing structures, including programmatic equipment	Yes, for anchorage and support design[5]
New anchorage or support for existing systems and components	Yes, for anchorage or bracing only

[4] PC-4 is not anticipated at LANL and is not addressed herein; Chapter 5 POC will provide such requirements should the need arise.

[5] This chapter primarily covers the design of supports and anchorage of nonstructural systems and components. This includes complete requirements for the seismic design of those supports and anchorage. In addition, the chapter does provide some information and requirements for the seismic design of the systems and components.

Renovations, modifications, repairs, alterations, or rehabilitation to existing structural systems and sub-systems	Yes[6]
Existing facility safety basis change	Yes, existing and new SSC shall be evaluated against these criteria
Existing structures (evaluation only, not design)	No (follow DOE-STD-1020, and ASCE 31)

B. **Projects which have not yet established their code of record** in accordance with ESM Chapter 1, Section Z10 on Code of Record (*Subsection 3.0*) shall revise their design criteria to reflect the latest revision of this chapter, and shall provide reference to the revisions of the Chapter 5 sections in their appropriate contract documents.

C. For projects **with a code of record established** per Section Z10, application of the seismic design criteria increase that first appeared in the June 2007 chapter revision depends upon the category of the facility or system as follows:

Non-Nuclear and Low Hazard Facility

- Projects which not yet received approval to start construction (e.g., CD-3) shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.
- In the special case of design-build projects which have received combined CD-2/3 approval but have not yet finalized design of structural elements which are part of the lateral-force-resisting system (i.e., issued PE-stamped final drawings), the project shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.
- For projects which have received CD-3 approval and have issued the final, stamped design for structural elements which are part of the lateral-force-resisting system, no change in criteria or evaluation is required. Construction may proceed in accordance with the final design. The impact of the June, 2007, seismic response spectra will be evaluated in conjunction with a separate project which assesses the impact of the updated hazard on existing facilities.

[6] Work done on existing PC-0, PC-1, and PC-2 SSCs shall be in accordance with the International Existing Building Code as amended by LANL; see also LANL ESM Chapter 16, IBC Program (IBC-GEN App B, LEBC). PC-3 work shall follow Structural Chapter Section III.

Moderate and High Hazard Facility

- Projects which have not yet received approval to start operations (e.g., CD-4) shall work with their DOE Federal Project Director before starting any risk evaluation to reach agreement to determine whether to follow the requirements above (for non-nuclear) or below (for nuclear) and, after completing the evaluation, consult with DOE to determine the course of action required to address the results. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed.

Nuclear Facility

- Projects which have not yet received approval to start operations (e.g., CD-4) shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.

For modification projects without a DOE Federal Project Director, consult the LANL Design Authority Representative who will consult with the appropriate SME.

D. The criteria in this Chapter are intended to be used in the design of structures and structural supports for equipment and distribution systems by licensed structural design engineers (requirements per ESM Chapter 1 Section Z10). The SSC shall be assigned to NPH performance categories[7] and/or seismic design categories by LANL prior to performing the structural design. Note that over the course of the structural design, some SSC may be reclassified in higher performance categories due to system interaction effects as discussed in Section 2.5 of DOE-STD-1021. SSC reclassified into higher performance categories will need to be checked against the corresponding higher NPH loads. The appropriate performance or seismic design category is a function of the safety or mission importance of the SSC. Criteria are presented in this chapter for:

- PC-0 , PC-1, PC-2, PC-3, SDC-1, SDC-2, SDC-3 and SDC-4 SSCs[8]
- Structural support and anchorage of PC-0, PC-1, PC-2, PC-3, SDC-1, SDC-2, SDC-3 and SDC-4SSCs

E. This Chapter is not intended for the design of non-structural systems and components. Refer to other chapters of the ESM for criteria that govern the design of electrical and mechanical components. The design requirements for the systems and components such as distribution systems or equipment (other than the support and anchorage) are presented in Chapter 2 (Fire Protection), Chapter 6 (Mechanical), and Chapter 7 (Electrical) as appropriate. This Chapter does address the structural and seismic analysis aspects of fire protection, architectural, mechanical, and electrical equipment, and distribution systems.

[7] For projects following DOE-STD-1189 for the seismic design basis, the NPH performance categories are replaced with NPH seismic design categories, and include both a limit state, as well as a seismic design category

[8] Separate criteria for PC-4/SDC-5 SSCs are not provided herein since LANL does not anticipate designing any PC-4/SDC-5 SSCs. Consult the Chapter 5 POC for PC-4/SDC-5 NPH criteria if it is needed on a project specific basis.

F. This chapter presents structural design criteria to be used in the design of structures and component supports against the effects of gravity loads, normal operating loads, natural phenomena hazard loads, and blast loads. The chapter presents minimum antiterrorism requirements as specified by the Department of the Defense (DOD) UFC 4-010-01. Minimum antiterrorism requirements should be considered for all facilities to the extent it is not cost prohibitive, but particular attention should be paid to antiterrorism requirements for those highly visible facilities and HC 2 or 3 nuclear facilities. The provisions in this chapter for blast are focused on structural design for blast loads. Blast loading criteria will be provided by LANL. These blast loads may either be intentional, as is the case for an experimental facility, or they may be accidental. LANL conducts experiments involving explosions and, for some of these experiments, a containment structure is provided to limit explosion effects on the surrounding area. The design of such containment structures is not within the scope of this chapter.

1.4 Exclusions

A. The provisions of this ESM apply to all LANL nuclear and non-nuclear facilities that are regulated by DOE. The following are exclusions[9] to the provisions of the ESM:

1. Requirements in this Order that overlap or duplicate requirements of the Nuclear Regulatory Commission (NRC) related to radiation protection, nuclear safety, (including quality assurance), and safeguards and security of material, do not apply to the design, construction, operations, and decommissioning of DOE facilities. This exclusion does not apply to requirements for which the NRC defers to DOE or does not exercise regulatory authority;

2. Pursuant to Executive Order (E.O.) 12344, Naval Nuclear Propulsion Program, the Director, Naval Nuclear Propulsion Program, will implement and oversee requirements of this Order for programs under the Directors cognizance as set forth in the Defense Procurement Reform Act of 1984 [Public Law (P.L.) 98-525] and the Military Lands Withdrawal Act of 1999 (P.L. 106-65);

3. Requirements of this Order that overlap or duplicate requirements of the Department of Transportation (DOT) do not apply. This exclusion does not apply to requirements for which DOT defers to DOE or does not exercise regulatory authority;

4. Activities under the Nuclear Explosives and Weapons Safety Program for prevention of accidental or unauthorized nuclear detonation are excluded from a requirement of this Order only if the requirement would compromise the effectiveness or safety of those activities.[10]

[9] From DOE O 420.1B.
[10] 49 CFR 173.3 “Shippers-General Requirements for Shipments and Packagings, U. S. Government Material.”

1.5 Chapter Contents and Conventions

A. This Chapter consists of four sections. Sections I, II, and III provide the structural design and analysis criteria for SSC at LANL. Section I provides general guidance, criteria, and background on structural design, quality assurance, and design documentation. Sections II and III provide more prescriptive criteria to be used in the actual structural design. Due to similarity of PC-0, PC-1, and PC-2 NPH requirements, the design of PC-0, PC-1, PC-2, SDC-1 and SDC-2 structures and the design of the structural support and anchorage of PC-0, PC-1, PC-2, SDC-1 and SDC-2 systems and components are addressed together in Section II. Similarly the design of PC-3, SDC-3 and SDC-4 structures and the design of the structural support and anchorage of PC-3, SDC-3 and SDC-4 systems and components are addressed in Section III. Section IV provides geotechnical requirements.

B. All text in regular type indicates mandatory requirements unless prefaced with wording identifying it as guidance or a recommendation. Where appropriate, guidance is provided to aid the cost-effective implementation of site-specific requirements and the requirements in the applicable codes. *Italicized* text identifies recommended guidance (not mandatory), based on good business practice and through lessons-learned at LANL. Footnotes throughout the chapter add commentary or additional background information on the basis of particular provisions.

1.6 Project Records for Structural Design

A. **Project Requirements for Structural Designs**

1. This Chapter (structural) of the ESM along with applicable building codes, DOE Orders and Standards, and applicable material standards and design manuals provide the basic project requirements for structural design projects. In addition, there are generally project specific design requirements provided by LANL. Project specific requirements may be in the following form:

   - Design bid package including the Request for Proposal (RFP)
   - Project functional requirements.
   - Facility safety analysis reports.
   - Project design criteria

2. All of these project requirements shall be referenced, where applicable, in the project submittals to LANL.

B. **Project Submittals**

1. Project records for structural design shall be prepared considering the concept of a graded approach where the level of detail and rigor is consistent with the importance to safety, mission importance, and project cost. The greatest level of detail and rigor is required in the design and documentation for SSC that are in ML-1 or ML-2 projects or are in systems designated as PC-3, SDC-3 or SDC-4. Lesser level of detail is acceptable for SSC in ML-3 or ML-4 projects or in systems designated as PC-0, PC-1 or PC-2 and SDC-1 or SDC-2. Extensive documentation is generally required for the structural design of new buildings.

2. If such buildings are classified as PC-3, SDC-3 or SDC-4, the structural design will be performed under close scrutiny by LANL and DOE reviewers such that the level of documentation is especially important and extensive documentation will generally be required. However, many LANL structural design projects may be simple efforts involving modifications to portions of buildings or installation of new equipment or systems in existing buildings. For these types of projects, it may be possible to document the structural design by drawings with notes along with structural calculations. For all structural design projects, large or small, all of the information described in this section must be documented in some manner.
3. The project records for structural design to be submitted to LANL shall consist of the following:
    - Design Basis Document (DBD)
    - Structural Calculations
    - Test and Inspection Requirements
    - Project Quality Assurance (QA) Plan
    - Construction Drawings
    - LANL Master Specifications
4. At a minimum, the DBD, construction drawings, and construction specifications shall be submitted to LANL for review. The review is conducted by the LANL Engineering Standards Chapter 5 Point of Contact (POC), or his/her designee, as the structural authority having jurisdiction for review and approval.

C. **Design Basis Document (DBD)**

1. The DBD provides a summary of the specific facility structural design basis and shall include the PC of the SSC being designed, design codes of record (dates and editions), methods (computer codes, analytical methods), load definition, load combinations, load path, member capacity equations, and corresponding applicable acceptance criteria. The DBD shall describe the design of building structures, non-structural components, equipment, and distribution systems. A sample format for a DBD is presented in Figure I - 1.
2. The DBD may be used to eliminate load combinations as described in Sections II and III from consideration by showing that they are either not applicable or bounded by other load combination equations. Once the design basis document is established, **it does not** have to be revisited during the project duration for changes or updates in the ESM or the referenced standards unless otherwise noted in the LANS/DOE Contract. Also see LANL ESM Chapter 1 Section Z10 on Code of Record.

- Facility Background and Mission*
- Facility Hazard Categorization and Basis per SBP111-1, *Facility Hazard Categorization and Documentation*
- Management Level for the Project per AP-341-502, R1*
- Assignment of SSC as Safety Class, Safety Significant, or Important to Safety and Assignment of SSC to NPH Performance Categories*
- Listing of Components for which Special Seismic Certification is Required.
- Facility Siting Considerations (standoff distance from known faults, flood levels, etc.)*
- Facility Geotechnical Investigation (e.g., highlight content of recommendations and how they are incorporated into foundation design, etc.)
- Natural Phenomena Hazard Definition
  - Earthquake (DBE ground response spectra)
  - Wind (peak gust speed)
  - Wind Driven Missiles (definition)
  - Snow
  - Flood and local precipitation (if applicable or basis for not considering)
- Antiterrorism Measures*
- Experimental Explosion Design Considerations
- Accidental Explosion Design Considerations
- LANL ESM Revision and Edition
- Design Codes and Standards of Record (Edition and Rev. Date)
- Rationale for Selection of Structural Systems
- Seismic design requirements for nonstructural components and nonbuilding structures, including applicability of, and exemptions to, requirements
- Analysis Methodology (Determination of Structural Demand)
- Member Capacity Equations Not Included in Design Codes or Not Commonly Used
- Load Combinations (may refer to Chapter 5 of the ESM)
- Load Path
- Means of Accounting for Inelastic Behavior During the DBE in the Seismic Analysis and in Design Detailing

* This information is typically found in other documents such as the Facility Design Description (FDD) or System Design Descriptions (SDD) and only a brief summary from these documents need be included in the DBD.

Figure I - 1 Design Basis Document Sample Format

3. In addition to describing the design basis for gravity loads, normal operating loads, and NPH loads, the DBD shall describe the design basis for blast loads and any antiterrorism measures implemented. Blast loads can result from either planned experiments or accidents involving explosives or flammable materials. The design blast loads, methods of analysis, and levels of acceptable blast damage shall be addressed in the DBD. Antiterrorism measures, if present, shall follow the minimum standards from the DOD UFC 4-010-01 and shall also be addressed in the DBD.

4. A PC or SDC must be assigned to an SSC to establish the appropriate NPH (earthquake, wind, and flood) design and analysis requirements as put forth in DOE-STD-1020 and DOE-STD-1189. These standards provide design criteria for three performance categories, PC-1 through PC-3 and four seismic design categories, SDC-1 through SDC-4. The assignment of NPH performance/seismic design categorization is accomplished using the guidance established in DOE-STD-1021 or, in the case of the earthquake hazard, ANSI/ANS 2.26. The basis for assignment of performance categories to SSC shall be either summarized or presented in detail in the DBD. The assignment of performance categories may be summarized when a safety analysis report exists that contains the detailed information. The assignment of performance categories shall be presented in detail when a separate document, such as a safety analysis report, does not present the basis for assignment of performance categories. NPH performance/seismic design categories will be provided to the structural designer by LANL.
5. A separate DBD is required for major structural design projects. Where the ESM is employed for the design of small buildings, equipment slabs, or structural components, etc., the contents of the DBD, as described above, may be included as front matter in the structural calculations.[11]

D. **Structural Calculations:**

1. Structural Calculations shall be performed, numbered, and approved in a consistent format as described in the Project QA Plan (see Section I 1.6.F and Figure I - 2) and shall include, at a minimum, sections for Purpose and Objective, Methodology and Acceptance Criteria, Assumptions, Design Input, References, Calculations, and Summary and Conclusions. Calculations may be performed by hand or by computer analysis. Computer analyses shall conform to the requirements given below. *One acceptable procedure for performing calculations for LANL is AP-341-605*[12] Structural Calculations shall be signed by a Preparer, a Checker (that attests to numerical accuracy), and an Approver (attests to reasonableness of the theory and assumptions and to the validity of the conclusions reached). The checker and approver may be the same individual but not the preparer. All structural design calculations shall be performed following a LANL approved QA program. The requirements of the QA program may be tiered for the various NPH performance categories by the graded approach philosophy.
2. *Calculations performed by computer analysis.* When computer analysis is performed, input and output shall be numbered in a consistent format as described in the Project QA Plan. The documentation for the computer analysis shall be included in the overall calculation, as described above. *Computer Input and Output files may be included in Attachments/Appendixes to the Calculation.* Preparer, Checker and Approver requirements are as described above. The documentation for computer analysis shall, at a minimum, include a brief description of the structural model, the loading, a figure showing the model configuration [with control nodes shown along with the most limiting structural components (members)], and how the results of the analysis are applied. The analysis input file and condensed output files directly used to support the analysis results shall be included. Additional output files may either be included or stored in an electronic

[11] The majority of LANL structural design projects are small and will not require a formal DBD.
[12] "Engineering Calculations," LANL ADE, AP-341-605, R0, 2007.

format. Documentation shall be sufficient to insure that a third party may take the input file and reproduce the analysis results. Also, documentation shall be sufficient to the extent that the reviewer can determine that the model is valid and that the results were properly interpreted.

E. **Test and Inspection Requirements**

Address the following (driven by ESM Chapter 16):

1. Special inspection (including AISC 341), structural test, and structural observation requirements shall be provided on the drawings, or in a stand-alone document, for new construction or modifications to existing SSC. Minimum requirements for special inspection, testing, and structural observation are given in ESM Chapter 16, IBC Program. The goal of these requirements is to ensure that construction is implemented in the manner intended by the structural design engineer.
2. LANL is in IBC Seismic Design Category D. The statement of special inspections developed by the registered design professional in responsible charge shall include additional requirements for seismic resistance as specified in IBC 1705.3, Seismic Resistance; IBC 1707, Special Inspections for Seismic Resistance; and IBC 1708, Structural Tests for Seismic Resistance. Special inspections are required for the seismic-force-resisting systems (per IBC 1705.3.1), the Designated Seismic Systems (IBC 1705.3.2), and several additional systems and components (IBC 1705.3.3 and 1705.3.4).

F. **Designated Seismic Systems**

1. Designated Seismic Systems are those architectural, electrical, and mechanical systems and their components that perform a seismic hazard mitigating function, based on the results of safety analysis or preliminary hazards analysis or for those components designed to the IBC and ASCE 7 for which the component importance factor, I_p is greater than 1.0.[13]
2. The design and documentation requirements for nonstructural components and systems vary, depending upon the importance of the system or component and whether the component is required to be functional immediately following the design earthquake (i.e., containment or operable).
3. For projects following DOE-STD-1189, the functional requirements of components (safety class, safety significant or important to safety) are normally specified in preliminary hazards assessment documents, or documented safety analysis. The design of those systems and components shall be in accordance with the requirements provided in Section III of this chapter.
4. For non-nuclear facilities, PC-1 and PC-2, there may not be associated safety documents that identify the required functionality of the Designated Seismic System. For many systems in PC-1 and PC-2 facilities, the application of the component Importance Factor greater than 1.0 is all that is required for the Designated Seismic System. Specifically, for PC-1 facilities and PC-1 SSCs, where the expected post-seismic consequence is that the facility will be damaged but not to the extent that life-safety is endangered, Special Certification of

[13] IBC 2009 1702.1

Designated Seismic Systems as defined in ASCE 7 is not required. The use of an importance factor of 1.5 is all that is required to provide an increased likelihood of operation of the specified systems and components. If, however, programmatic concerns or a hazard analysis identifies that the Designated Seismic System must remain functional (i.e., operate or confine hazardous materials) following the design basis earthquake, Special Certification per ASCE 7 is required.

5. A list of components requiring Special Certification shall be provided on the construction drawings or specifications, and the Design Basis Document for new construction or modifications to existing SSCs. The basis for the functionality requirement shall also be provided in the Design Basis Document.

G. **Project Quality Assurance Program (QAP)**

The following sections describe the QAP and Peer Review requirements for the structural aspects of a project. The QA and peer review should be conducted within the framework of a graded approach with increasing level of rigor employed from PC-0 to PC-4 facilities. These requirements shall be documented in a Project QAP. A sample format covering the required structural design elements of a project for the Project QAP is presented in Figure I - 2.

1. **QA Requirements:**

a. The LANL basic QAP requirements are described in LANL SD 330 which invokes NQA-1 and 10 CFR Part 830 (Subpart A, Quality Assurance Requirements) for nuclear facility applications and DOE Order 414.1C (CRD/Att. 2 Section 3.f.6 deals with design QA) for non-nuclear-related facilities. A QAP that, at a minimum achieves the DOE/LANL QA requirements for specifications, drawings, procedures, and instructions shall be used. The basic elements of the structural analysis and design QAP shall address the following:

- Design Organization: Analysis team, division of responsibility, team interface control, and organizational procedures and standards.
- Design Procedures
- Design Basis Document
- Methods for Design Verification
- Design reviews and independent peer review
- Design output documents (i.e., drawings, specifications, and calculations)
- Design document control

b. The QAP shall at a minimum include provisions for verifying and checking the adequacy of the analysis and design either by directly checking the original analysis and verifying the underlying assumptions, or by use of alternate or simplified calculation methods or the performance of a suitable testing program or by the performance of design reviews.

QA PLAN

- QA Requirements for Project (May refer to a manual, rev. and date)
- Project and QA Team Qualifications
- QA Training Requirements
- Design Basis Document Requirements
- Design Procedures
- Calculation Requirements (may refer to a LANL master specification)
- Computer Analysis Requirements (may refer to a LANL master specification)
- Inspection, Observation, and Testing Requirements
- Drawing/Specification Requirements (including New Mexico PE Stamp requirements)
- Document Control and Records Management
- Design Review and Independent Peer Review
- Application of Graded Approach for QA Process
- Work Processes

PEER REVIEW PLAN

- Peer Reviewer Qualifications
- Scope of Peer Review Process (When, What, and Where)
- Format of Final Report from Peer Reviewer
- Application of Graded Approach for Peer Review Process

Figure I - 2 Structural Design Project QA Plan and Peer Review Samples Format

2. **Peer Review Plan**

a. Qualified LANL staff will review PC-0 and PC-1 SSC. Qualified LANL staff or external expert consultants, hired by the Laboratory, will be engaged to peer review the design and analysis of PC-2, PC-3, SDC-2, SDC-3 and SDC-4 SSC. In all cases, the project peer reviewer shall not be engaged in design activities for the project. Peer review is in addition to the design review performed in the QA portion of the project and provides an independent evaluation of the design. Peer review shall be performed by either internal and/or external personnel with recognized technical credentials concerning the unique features of the design and analysis. The peer review effort may be performed in series or in parallel with the design or analysis process. *However, for most projects, it is recommended that peer review should be performed in parallel.*[14] The Peer Review Plan will include the requirements for Structural Calculations, Computer Analyses, and Test and Inspection Requirements as discussed above.

b. A graded approach shall be used so the scope of the review, including the number of reviewers engaged, is consistent with the complexity of the design, the number of disciplines involved, and the uncertainty in the data.

[14] For large projects, it is recommended that the peer review effort should at least include a review of the DBD, sample calculations performed early in the project, specialized or unique calculations and the final documentation at the end of the project. This enables the peer review effort to have a positive effect on the project throughout and minimizes re-work and surprises at the end of the project.

c. Peer Review of the analysis of the structural system used to verify the proposed design should consider the following elements:

- Applied loads
- Adequacy of model
- Assumptions upon which the model is based
- Use of the results from the analysis
- Appropriateness of the solution technique or analysis software
- Adequacy of horizontal and vertical load paths
- Proper inclusion of the geotechnical investigation into the analysis

H. **Construction Drawings:**

1. Construction drawings for new design and modifications to existing design shall be prepared in accordance with the LANL Drafting Manual. Applicable codes and manuals and design criteria shall be provided on the general structural notes sheet of the drawing set. Codes and manuals and project design requirements, including their edition or date, used for the structural design shall be listed. Also, vertical (e.g., dead load, live load, etc.), horizontal (e.g., wind loads), and seismic loads used in the design shall be listed.

I. **Master Specifications** (Programmatic and Facility)**:**

1. Construction specifications for new design and modifications to existing design shall be prepared to provide project specific construction requirements associated with the structural design of the building and the construction/installation of supports and anchorage for systems and components. The specifications shall include all applicable requirements in the templates provided in the LANL Master Specifications Manual.[15]

2. The LANL Standards Program maintains standard specifications for those that provide and construct PC-0, PC-1, PC-2. SDC-1 and SDC-2 building structures as well as certain nonstructural components at the LANL site. These specifications should be edited to suit the particular project; however, when editing, author shall add job-specific requirements and delete only those portions that do not apply to the Project (e.g., a component that does not apply). To seek a variance from applicable requirements, contact the Engineering Standards Structural POC.

   Available Master Specifications include:

   Section 03 1512 – Post-installed Concrete Anchors Purchase – High Confidence
   Section 03 1534 – Post-installed Concrete Anchors Purchase – Normal Confidence
   Section 03 1550 – Post-installed Concrete Anchors – Installation and Testing
   Section 03 3001 – Reinforced Concrete
   Section 03 3053 – Miscellaneous Cast-in-place Concrete [civil work]
   Section 04 2220 – Reinforced Unit Masonry
   Section 05 1000 – Structural Metal Framing
   Section 05 1305 – Stainless Steel
   Section 05 2100 – Steel Joist Framing
   Section 05 3000 – Metal Decking
   Section 05 4000 – Cold-Formed Metal Framing
   Section 05 5000 – Metal Fabrications

[15] For small structural design projects, specifications may be in the form of notes on the drawings.

Section 05 5213 – Pipe and Tube Railing
Section 05 5350 – Gratings and Floor Plates
Section 13 3419 – Metal Building Systems
Section 13 4800 – Sound, Vibration, and Seismic Control
Section 22 0529 – Hangars and Supports for Plumbing Piping and Equipment
Section 22 0548 – Vibration and Seismic Controls for Plumbing Piping and Equipment
Section 26 0529 – Hangars and Supports for Electrical Systems
Section 26 0548 – Vibration and Seismic Controls for Electrical Systems
Section 41 2213.13 – Bridge Cranes
Section 41 2225 – Hoists and Trolleys

NOTE: The specifications were developed for ML-4, PC-0, and PC-1 projects. For ML-1/ML-2/ML-3, PC-2, and PC-3, SDC-2, SDC-3 and SDC-4, additional requirements and QA reviews are normally required. Refer to ASCE/SEI-43 Section 9.0, Seismic Quality Provisions, for guidance.

1.7 Codes and Standards

A. Refer to ESM Chapter 1 Section Z10 if there is a conflict between codes, standards, and LANL requirements.

B. Refer to Chapter 1 Section Z10 for interpretation and variances to the LANL Standards.

C. **Codes of Record and Additional References**

1. The user of the ESM shall comply with the code edition referenced herein (Subsection I.1.B) or the latest edition at the time of design contract RFP (or design initiation in the case when LANL staff is performing the design or evaluation). That same code edition will normally be used throughout the project's design and construction. The DBD shall identify the exceptional cases where the code edition is updated while project design and construction phases are ongoing shall take precedence over code editions in effect at project start. The edition of the codes and standards used in the design shall be referenced in the DBD as noted in Subsection 16.C. The codes, standards, laws, orders, and additional references (publications and papers) presented in 4.0 are used in the evaluation of SSCs as described in this Chapter.
2. If there is a conflict between the referenced codes, standards, and LANL structural design requirements in this manual, contact the LANL Engineering Standards Chapter 5 POC for assistance in resolving the conflict.
3. If there is a conflict between the referenced books, papers and report, and LANL structural design requirements in this manual, the LANL ESM requirements shall govern.[16]

[16] The papers, books and reports referenced are normally used in this Chapter for narrow technical issues. The provisions of this Chapter are included to be consistent with the governing consensus code or standard not individual papers, books or reports.

D. **LANS/DOE Contract (Programmatic and Facility)**:

- A number of contractually-required Order and standards are contained in the LANS/DOE Contract Appendix G.
- Comply with the edition and addenda(um) in effect on the effective date noted in the LANS contract unless otherwise noted, and the latest edition of the CFRs.

  http://www.doeal.gov/laso/NewContract.aspx or internally http://int.lanl.gov/orgs/pcm/

E. **Conduct of Engineering, PD340**

LANL organizations are required to follow the primary manual and the three companion manuals:

- **Primary Manual: STD-342-100, LANL Engineering Standards Manual.** The LANL Engineering Standards Manual is arranged by discipline specific chapters and provides site-specific engineering requirements, guidance, and design criteria for LANL facilities.
- **Companion Manual: LANL Master Specifications, STD-342-200**: The LANL Master Specifications Manual provides templates for the preparation of project specific construction specifications at LANL. These documents are referenced throughout the ESM. The specifications shall be edited to reflect the scope of the project. Variances taken by the engineer/designer for a portion of an applicable Master Specification template shall be approved by the LANL Engineering Standards Chapter 5 POC.
- **Companion Manual: LANL Drafting Standards Manual, STD-342-300**: The LANL Drafting Manual provides drafting requirements for use when creating or revising construction drawings for LANL construction projects and preparing as-built drawings
- **Companion Manual: LANL Standard Drawings and Details, STD-342-400**: The LANL Standard Drawings and Details provide standard drawings and details for preparation of the construction drawings.
- The four manuals are available at http://engstandards.lanl.gov/index.shtml

2.0 ACRONYMS AND NOTATIONS

The following is a list of acronyms, notation, symbols, and shortened titles used in this Chapter. Load-related symbols and factors are defined in Section II.1A and III.1A.

AA – Aluminum Association

AASHTO – American Association of State Highway and Transportation Officials

ACI – American Concrete Institute

ADM – Aluminum Design Manual

AISC – American Institute of Steel Construction

AISI – American Iron and Steel Institute

ANSI – American National Standards Institute

API – American Petroleum Institute

ASCE – American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM – American Society of Testing Materials

ASD – Allowable Stress Design

ATC – Applied Technology Council

ASME – American Society of Mechanical Engineers

AWS – American Welding Society

BLEVE – Boiling Liquid Expanding Vapor Explosion

BNL – Brookhaven National Laboratory

CE – Carbon Equivalent

CIP – Cast in place

CFR – Code of Federal Regulations

DBD – Design Basis Document

DBE – Design Basis Earthquake

DOD – Department of Defense

DOD-TM - Department of Defense Technical Manual

DOE – Department of Energy

DOE G – Department of Energy Guideline

DOE M – Department of Energy Manual

DOE-STD – Department of Energy Standard

DOT – Department of Transportation

ESM – Engineering Standards Manual

F_μ – Inelastic Energy Absorption Factor

FDD – Facility Design Description

FEMA – Federal Emergency Management Agency

FIMS – Facility Information Management System

FS – Factor of Safety

HC – Hazard Category

HVAC – Heating Ventilation and Air Conditioning

I – Importance Factor

IBC – International Building Code

ICC – International Code Council

ICC ES – International Code Council Evaluation Service

IEBC – International Existing Building Code

IEEE – Institute of Electrical and Electronics Engineers

IMP – Implementation procedure

ISD – Implementation Support Documents

LANL – Los Alamos National Laboratory

LANS – Los Alamos National Security, LLC

LLNL – Lawrence Livermore National Laboratory

LRFD – Load & Resistance Factor Design

ML – Management Level

$N_{allowable}$ – Allowable strength in tension

N_n – Nominal strength in tension

NASPEC – North American Specification

NEMA – National Electrical Manufacturers Association

NFPA – National Fire Protection Association

NNSA – National Nuclear Security Administration

NPH – Natural Phenomena Hazard

NRC/NUREG – Nuclear Regulatory Commission

PC – Performance Category

PI – Post-installed

POC – Point of Contact

QA – Quality Assurance

QAP – Quality Assurance Program

R, R_p – Response Modification Coefficient

RFP – Request for Proposal

SD – Strength Design

SDC – Seismic Design Category

SDD – System Design Description

S_{D1} – Response Spectral Acceleration at 1 Second Period

S_{DS} – Peak Response Spectral Acceleration (0.2 Second Period)

SF – Scale Factor

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

SSC – Structures, Systems, and Components

TEMA – Tubular Exchanger Manufacturers Association

UFC – Unified Facilities Criteria

UHRS – Uniform Hazard Response

Spectrum

V – Basic Wind Speed

$V_{allowable}$ – Allowable strength in shear

V_n – Nominal strength in shear

ϕ – Capacity Reduction Factor

l – Reduction Factor for Concrete Cracking

3.0 DEFINITIONS

Anchor – A steel element either cast into concrete or masonry or post installed into a hardened concrete or masonry member. Including headed bolts, hooked bolts (J- or L- bolt), headed studs, expansion anchors, or undercut anchors. Anchors in the context of the ESM also include steel to steel connection elements and welds. Anchors are used to transmit applied loads.

Anchorage – A device or a collection of devices that provide structural support or restraint for systems and components to prevent falling, sliding, overturning, and excessive displacement.

Attachment – The structural assembly, external to the surface of the concrete that transmits loads to or receives loads from the anchor.

Exceedance Frequency – The annual probability of exceeding a given ground motion. For example, at LANL, the mean exceedance frequency associated with a peak ground acceleration of 0.34g is 4×10^{-4} (i.e., 1/2500) or an average return period of 2,500 years.

Existing Facility – A facility that has received authorization to operate on or before the effective date of this ESM Chapter, or if authorization is not required, a facility that has begun normal operation on or before the effective date of this ESM Chapter.

Facility – One or more building(s) or structure(s), including systems and components, dedicated to a common function (includes operating, non-operating, and facilities slated for decontamination and decommissioning).

Inelastic Energy Absorption Factor (F_μ) – A factor used to reduce linearly estimated demand to account for limited inelastic behavior in PC-3 and PC-4 SSCs. The Inelastic Energy Absorption Factor is a function of the target limit state and the structural system configuration.

Graded Approach – A process by which the level of analysis, documentation, and actions necessary to comply with requirements are commensurate with: the relative importance to safety, safeguards, and security; the magnitude of any hazard involved; the life cycle stage of a facility; the programmatic mission of a facility; the particular characteristics of a facility; and any other relevant factor.

Hazard – A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to an operation or to the environment (without regard for the likelihood or credibility of accident scenarios or consequence mitigation).

High Confidence of Low Probability of Failure (HCLPF) – Usually a 90% confidence of a less than 10% probability of failure which results in about a 1% to 2% probability of failure

Limit State – The limiting acceptable condition of the SSC. The limit state may be defined in terms of a maximum acceptable displacement, strain, ductility, or stress.

Mean Annual Hazard – The expected (or average) exceedance frequency associated with a given hazard. Future seismic loads are highly variable. For a given site, there is typically, a “mean annual seismic hazard” curve that expresses the average (or expected) value of a ground motion parameter, such as peak ground acceleration, as a function of the probability of exceedance of that variable.

Natural Phenomena Hazard (NPH) – An act of nature (e.g., earthquake, wind, tornado, flood, precipitation, volcanic eruption, or lightning strike) that poses a threat or danger to workers, the public, or to the environment by potential damage to structures, systems, and components.

New Facility – A DOE facility that does not qualify as an existing facility.

Peak Spectral Acceleration – The maximum acceleration response that a prescribed forcing function can produce in a single degree of freedom oscillator (independent of the natural frequency of the oscillator).

Peer Review – A formal review process in which an external party (independent from the project) will review the methodology, results, and process by which a design is developed.

Post-installed anchor – An anchor installed in hardened concrete. Expansion anchors and undercut anchors are examples or post-installed anchors.

Response Modification Coefficient (R) – A factor used to reduce demand to account for limited inelastic behavior and other factors (e.g., overstrength, redundancy) in PC-1 and PC-2 SSCs. The Response Modification Coefficient is a function of the structural system configuration.

Safety Class – A category for facilities or structures, systems, and components identified by a safety analysis whose importance to safety is to prevent or mitigate potential adverse consequences to the general public or the environment.

Safety Significant – A category for facilities or structures, systems, and components identified by a safety analysis whose importance to safety is to prevent or mitigate potential adverse consequences to the facility workers or occupants.

Seismic Hazard Curves (HC) – Description of the ground motion parameter of interest as a function of annual frequency of exceedance. Peak ground acceleration and spectral accelerations at 0.2 sec and 1 second natural period plotted as a function of annual frequency of exceedance are common. The seismic hazard curves are determined from a probabilistic hazard assessment following the guidance in DOE-STD-1022 and DOE-STD-1023.

Spectral Acceleration – The maximum acceleration response of a single-degree or freedom oscillator of a know frequency, f and viscous damping, β, subjected to a prescribed forcing function.

Structural Element – Portion of a structure such as a beam column, brace, anchor or support (pipe or cable tray, etc.).

Structural Lead Engineer – Engineer appointed to lead the structural design activities for a project.

Structures, Systems, and Components (SSC) – A structure is an element or a collection of elements to provide support or enclosure (such as a building, free-standing tank, basins, dikes, or stacks). A system is a collection of components assembled to perform a function (such as piping, cable trays, conduits, or HVAC. A component is an item of equipment (such as a pump, valve, or relay, or an element of a larger array such as a length of pipe, elbow, or reducer).

4.0 REFERENCES

Note: Expectation is use latest except for those referenced by building code of record.

ACI (American Concrete Institute)

- ACI 318, "Building Code Requirements for Structural Concrete," Code and Commentary, 2008
- ACI 349, "Code Requirements for Nuclear Safety Related Concrete Structures," Code and Commentary, 2006
- ACI 349.1R, "Reinforced Concrete Design for Thermal Effects on Nuclear Power Plan Structures," 2007
- ACI 530, "Building Code Requirements and Specification for Masonry Structures", 2008
- TMS 402 and 602/ACI 530 and 530.1/ASCE 5 and 6, "Building Code Requirements for Masonry Structures," and "Specification for Masonry Structures," respectively, 2008

AISC (American Institute of Steel Construction)

- AISC 341 – Seismic Provisions for Structural Steel Buildings, including Supplement 1, 2005.
- AISC 360 – Specification for Structural Steel Buildings, 2005.

AISI (American Iron Steel Institute)

- AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members," 2007
- AISI S200, "North American Standards for Cold-Formed Steel Framing – General Provision," 2007
- AISI S210,"North American Standard for Cold-Formed Steel Framing - Floor and Roof System Design," 2007
- AISI S211, "North American Standard for Cold-Formed Steel Framing - Wall Stud Design," 2007
- AISI S212, "North American Standard for Cold-Formed Steel Framing - Header Design," 2007
- AISI S213, "North American Standard for Cold-Formed Steel Framing – Lateral Design," 2007
- AISI S214, "North American Standard for Cold-Formed Steel Framing - Truss Design," 2007 with Supp 2

ANSI/AISC (American National Standards Institute/ American Institute of Steel Construction)

- ANSI/AISC N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities, 2005.

ANSI/ANS (American National Standards Institute/American Nuclear Society)

- ANSI/ANS 2.26 "Categorization of Nuclear Facility Structures, Systems and Components for Seismic Design," 2004

ASCE (American Society of Civil Engineers)

- ASCE 4, "Seismic Analysis of Safety Related Nuclear Structures and Commentary," 1998.
- ASCE 7, "Minimum Design Loads for Buildings and Other Structures," 2005.
- ASCE 8, "Specification for the Design of Cold-Formed Stainless Steel Structural Members," 2002.
- ASCE 19, "Standard Guidelines for the Structural Applications of Steel Cables for Buildings," 1996.
- ASCE 31, "Seismic Evaluation of Existing Buildings," 2003.
- ASCE 41, "Seismic Rehabilitation of Existing Buildings," including Supplement 1, 2006.
- ASCE 43, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities," 2005.
- ASCE, "Design of Blast Resistant Buildings in Petrochemical Facilities," Task Committee on Blast Resistant Design, 1997.
- ASCE, "Structural Design for Physical Security, State of the Practice," 1999.American Society of Civil Engineers, "Structural Analysis and Design of Nuclear Plant Facilities, Manuals and Reports on Engineering Practice No. 58, 1980.

ASME (American Society of Mechanical Engineers)

- NQA-1, "Quality Assurance Requirements for Nuclear Facility Applications," March 14, 2008 with 2009 addenda.
- QME-1, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," 2007.

ASTM (American Society of Testing Materials International)

- ASTM E 448, "Standard Practice for Scleroscope Hardness Testing of Metallic Materials," July 1982 (R 2008).
- ASTM G 57, "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method," 2006.

ATC (Applied Technology Council)

- ATC-40, "Seismic Evaluation and Retrofit of Concrete Buildings," 1996

DOD (Department of Defense)

- UFC 3-340-01, "Design and Analysis of Hardened Structures for Conventional Weapons Effects," Unified Facilities Criteria (UFC), 2002.
- UFC 4-010-01, "DoD Minimum Antiterrorism Standards for Buildings," Unified Facilities Criteria (UFC), October 8, 2003.

- UFC 4-010-02, "DoD Minimum Antiterrorism Standoff Distances for Buildings, Unified Facilities Criteria (UFC), January 2007.
- UFC 3-340-02, "Structures to Resist the Effects of Accidental Explosions, Unified Facilities Criteria (UFC), December 2008.

DOE (Department of Energy) Regs, Orders, and Standards (Programmatic and Facility)

- 10 CFR Part 830, "Nuclear Safety Management," 2006.
- DOE O 414.1C, "Quality Assurance," 2005.
- DOE O 420.1B, "Facility Safety," 2005.
- DOE G 420.1-2, "Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Nonnuclear Facilities," April 2000.
- DOE M 440.1-1A, "Explosive Safety Manual," 2006.
- DOE-STD-1020, "Natural Phenomena Hazards Design and Evaluation Criteria for DOE Facilities," January 2002.
- DOE-STD-1021, "Natural Phenomena Hazards Performance Categorization Criteria for Structures, Systems and Components," April 2002.
- DOE-STD-1022, "Natural Phenomena Hazards Site Characterization Criteria," April 2002.
- DOE-STD-1023, "Natural Phenomena Hazards Assessment Criteria," April 2002.
- DOE-STD-1189, "Integration of Safety into the Design Process," March, 2008
- DOE/EH-0545, "Seismic Evaluation Procedure for Equipment in the US DOE Facilities," March 1997.

EPA (Environmental Protection Agency)

- 40 CFR Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," 2002.

FEMA (Federal Emergency Management Agency)

- FEMA 350, "Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings", June, 2000.

ICC (International Code Council)

- IBC, "International Building Code 2009," Copyright 2009, Second Printing May 2009.
- IEBC, "International Existing Building Code 2009"

IEEE (Institute of Electrical and Electronics Engineers)

- IEEE 323, "Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," September 2003.
- IEEE 344, "Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," December 2004.

- IEEE 382, "Standard for Qualification of Actuators for Power-Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants," December 6, 2006.
- IEEE 628, "Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations," January 2001.

NUREG (U.S. Nuclear Regulatory Commission)

- NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," U.S. Nuclear Regulatory Commission, May 1979.

Miscellaneous References

[1] Adams, T.M., et al, "A Proposed Procedure for Buried Safety Related Piping at Nuclear Power Facilities," Presented at the 1998 ASME PVP Conference, San Diego, CA, 1998.

[2] American Institute of Chemical Engineers, "Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs," Center for Chemical Process Safety (CCPS), 1994.

[3] Antaki, G., "A Review of Methods for the Analysis of Buried Pressure Piping," Welding Research Council (WRC) Bulleting 425, New York, New York, September 1997.

[4] Bowen, B., "Los Alamos Climatology," Report No.: LA-11735-MS, Los Alamos National Laboratory, Los Alamos, New Mexico, May 1990.

[5] Brookhaven National Laboratory (BNL), "Seismic Design and Evaluation Guidelines for the DOE High-Level Waste Storage Tanks and Appurtenances," K.Bandyopadhyay et al, BNL Report No.: BNL-52361, October 1995.

[6] Cuesta, I., "Design-Load Basis for LANL Structures, Systems, and Components," LANL Report No.: LA-14165, September 2004.

[7] URS Corporation Seismic Hazards Group, "Update of the Probabilistic Seismic Hazard Analysis and Development of Seismic Design Ground Motions at the Los Alamos National Laboratory," prepared for Los Alamos National Laboratory, Job No. 24342433, 2007, LA-UR-07-3965, 25 May 2007.

[8] Lawrence, E., "Site-Specific Extreme Rainfall and Snow Hazard Curves at Los Alamos National Laboratory, Los Alamos, New Mexico," LANL Report No. LA-UR-06-6357, September 2006.

[9] LANL Calculation SB-DO: CALC 08-038, 10/8/08 (derives spectra from URS report LA-UR-07-3965)

[10] LANL Calculation SB-DO: CALC-09-024, Rev. 0, 10/19/09, "Development of TA-55 Structural Design Response Spectra."

APPENDIX A – ANCHORS FOR NON-BUILDING COMPONENTS

In addition to the need for anchorage for building-related components governed by the IBC, LANL requires that other SSCs be anchored in many instances. The flowchart below addresses these circumstances, and it is followed by addition information on R&D/programmatic anchorage requirements.

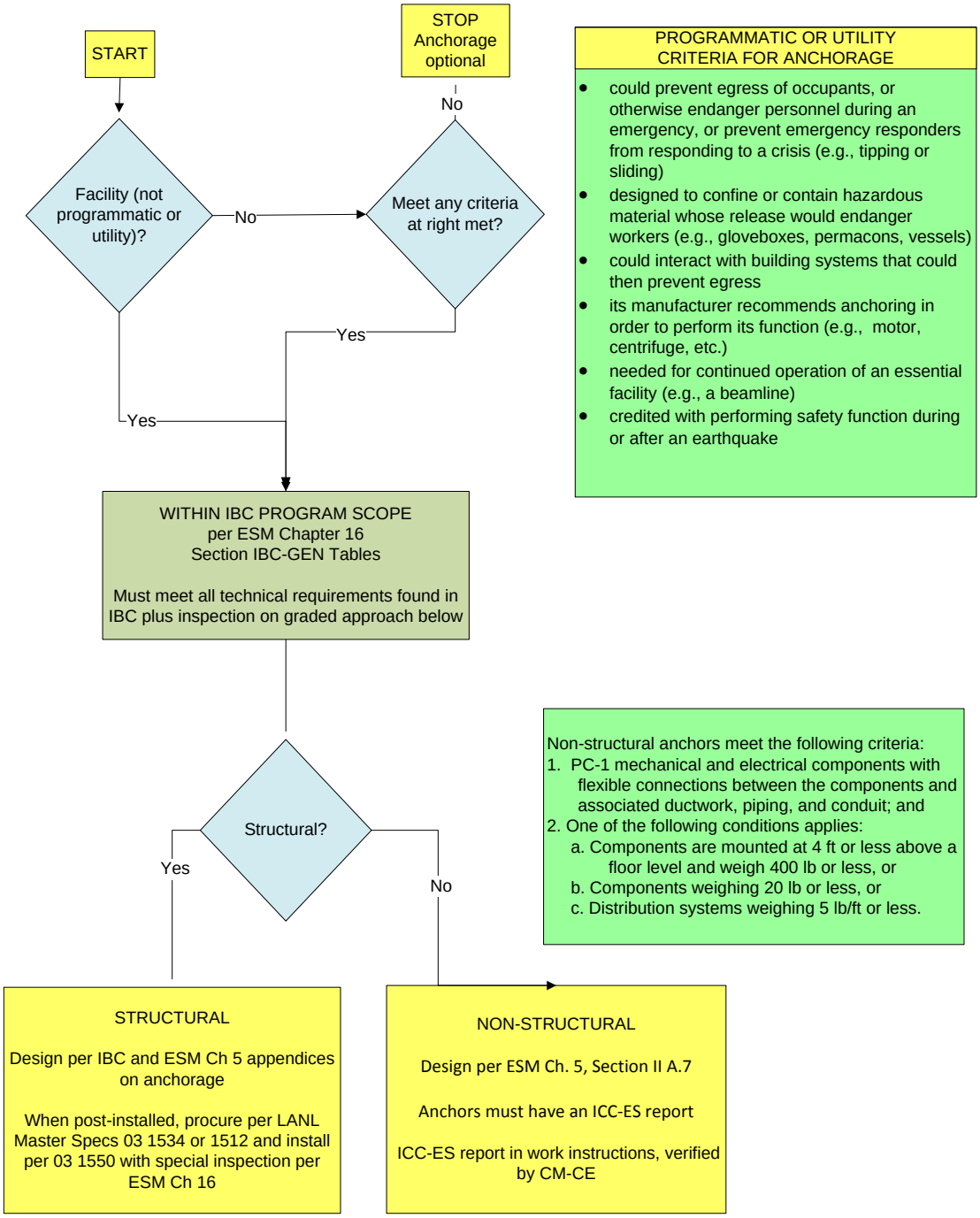

Figure I.A - 1 Non-Building SSC Anchorage Requirements

R&D/programmatic equipment is defined as manufacturing, process, or production equipment of LANL organizations, as distinguished from building services equipment.

Building services equipment includes plumbing, heating, electrical, ventilating, air conditioning, refrigerating, fire protection equipment, elevators, boilers, pressure vessels, and other mechanical and electrical systems or components required to make a facility fully functional for the required occupancy.

In general, programmatic equipment is exempt from the anchorage requirements in the model building codes. This exemption does not apply however to the following:

1. Equipment that is designed to confine or contain hazardous material (either radiological, chemical, biological, or other) whose release would endanger workers or the public
2. Equipment that is credited with performing a safety function either during or after the design basis earthquake
3. Equipment needed for continued operation of essential facilities
4. Equipment that could prevent egress of occupants or otherwise endanger personnel during an emergency in a facility or that could prevent emergency workers from responding to a crisis.
5. Equipment that could interact with other building systems that could prevent egress
6. The equipment manufacturer recommends anchorage to ensure operability or personnel safety

The design of anchorage for non-exempt equipment must comply with the seismic design requirements for non-structural components as presented in ASCE and implemented in the Engineering Standards Manual (ESM). Note that there are exceptions for anchoring of permanent equipment in ASCE 7.

Please refer to the following flow chart for a graphical representation of this information.

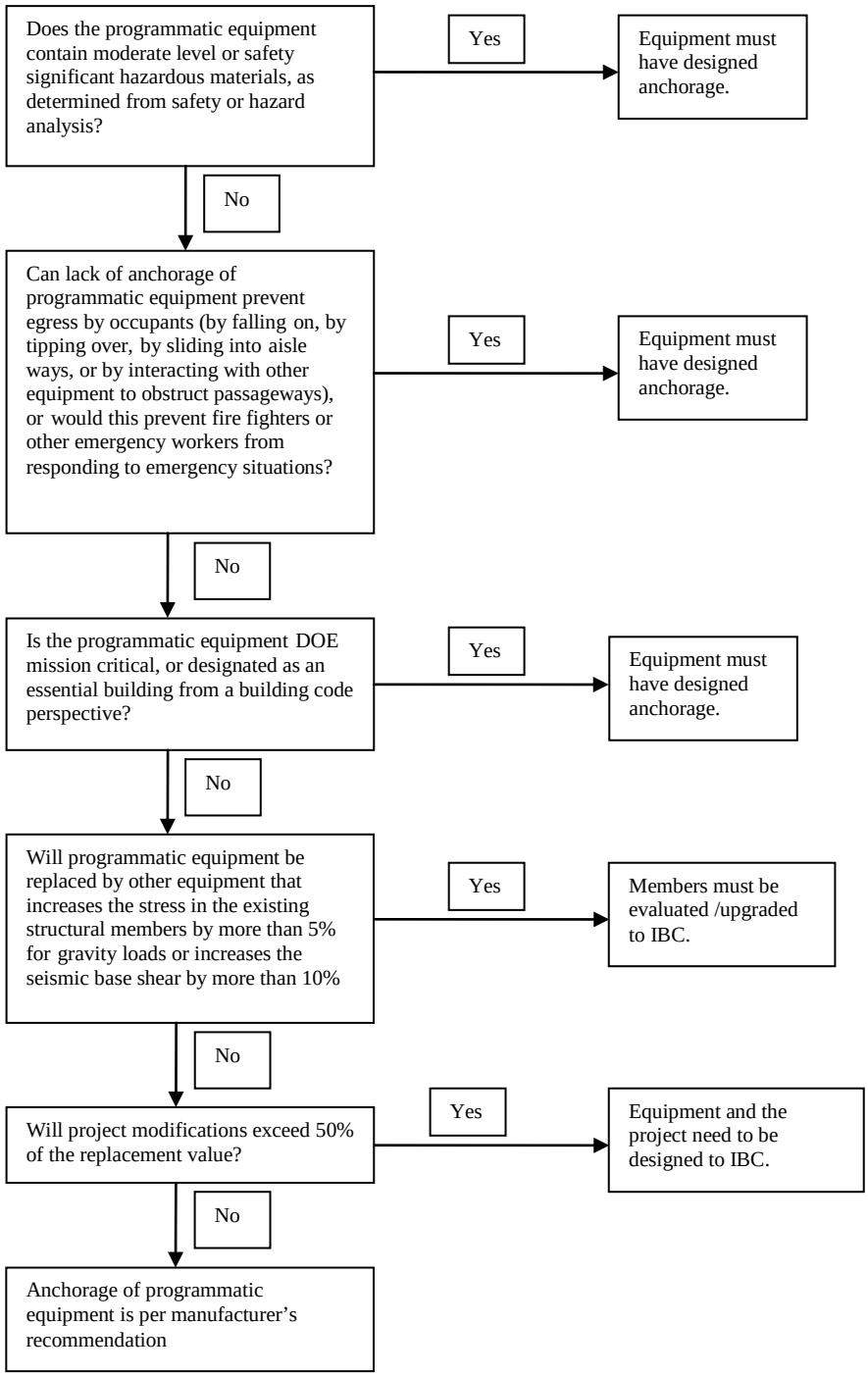

Figure I.A - 2 Non-Building SSC Anchorage Requirements -- Detail