# LANL Tailored Standards Manual (TSM)

STD-342-600

*An Alternative to the Engineering Standards Manual*
*for Commercial-Type Work Available to*
*Projects Meeting Scope/Applicability Conditions*

## TABLE OF CONTENTS

## REVISION RECORD

| Rev | Date | Description | POC | OIC |
|---|---|---|---|---|
| 0 | 05/27/2021 | Initial issue. | Tobin Oruch, *ES-FE* | Jim Streit, *ES-DO* |
| 1 | 12/23/2022 | Revised cost to under $50M from $20M and applicability to “commercial construction” concept. Updated and expanded throughout including systems engineering. Incorporated VARs 10526 GN restrooms and 10564 on TIP development. | Tobin Oruch, *ES-FE* | Michael Richardson, *ES-DO* |
| 2 | 12/24/2024 | Updated to adopt IBC 2021. Chapter 5 aligned to ESM Chapter 5, Section II, Rev 13 incorporating VAR-10711 (updated seismic design parameters $S_{Ds}$ and $S_{D1}$). Chapter 14 aligned to ESM Chapter 14, Rev 12.1. GLOS-COE-1 referenced vice App. A. | Tobin Oruch, *ES-FE* | Michael Richardson, *ES-DO* |
| 3 | 03/31/2025 | Major revision. Scope/Applicability expanded to generally match SD 413.3-7 ($100M, no nuclear/rad). Requirements added to address use with other hazards and general updating. Usage justification eliminated, canceling VAR-10466R1. Updates throughout. Att. 1 added for cost escalation. For LANL use, selected requirements were numbered and bases captured in associated spreadsheet. | Tobin Oruch, *ES-FE* | Michael Richardson, *ES-DO* |

# Chapter 1 GENERAL

## 1.0 SCOPE/APPLICABILITY

A. This document may and should be used in lieu of the complete LANL Engineering Standards (including LANL Engineering Standards Manual [ESM], STD-342-100) when all the following are met[1]:

1. total project cost (TPC) $100M maximum.
2. non-nuclear; no radiation hazards[2].
3. no critical technology elements as defined in DOE Guide (G) 413.3-4A, *Technology Readiness Assessments Guide* [archived], or NNSA Policy (NAP) 413.4, *Technology Readiness Assessments*.
4. not part of a phased set of projects as defined in DOE O 413.3 *(Appendix C, Section 28.b*), nor requires integration with other projects to provide a complete and usable product.

*Guidance: Typical facilities: office building, fire station, warehouse, many laboratories, parking garage, library, cafeteria, maintenance facility, fabrication shop, auditorium, multiuse facilities. Outside facilities: new construction, replacement or extension of utility system, road, curb, sidewalk, pedestrian overpass.*

B. For only those portions specifically invoked by this document, comply with the requirements in the project-scope-applicable portions of the LANL Engineering Standards Manual (ESM) STD-342-100, LANL Master Specifications STD-342-200, and LANL Standard Drawings and Details STD-342-400 and any web-published variances against those documents.

*Guidance: The TSM contains the minimum acceptable requirements[3]; however, users may elect to exceed them, including following aspects of the LANL Engineering Standards that are not invoked by reference. For example, users may elect to follow the entire set of LANL Master specification sections to ensure compliance with LANL-adopted codes, standards and LANL-specific requirements as well as alignment with 01 3300 Attachment A Construction Submittal Log and ESM Chapter 16 IBC-IP Attachment I, Test and Inspection Plan template.*

*The full Standards are available for use including additional context, and guidance at engstandards.lanl.gov.*

C. Requirement reductions and clarifications in ESM Ch. 1 Z10 on topics corresponding to TSM requirements may be applied with Engineering Standards Discipline POC permission.

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[1] TSM applicability is an interpretation of SD 413.3-7's applicability. Note, the SD also has a condition that "The project has no hazards above those that can be addressed using 10 CFR 851.23 safety and health standards;" however, that CFR part sets no hazard limits (only invokes selected codes and standards applicable to them, as does the TSM. Thus, that SD condition is not cited.

[2] Thus, not even DOE-STD-1027 "Below (less than) Hazard Category 3 (<HC-3) or Radiological." Sealed sources allowed if facility follows DOE-STD-1027 conditions (§3.1.2 in 2018 CN1). ML-1 and ML-2 are excluded from TSM use, but ML-4 as well as ML-3 not associated with a nuclear or rad facility safety basis is allowed (e.g., due to mission score, environmental matter).

[3] The most important contractual and preferential requirements for safety, operability, maintainability, and cost-effectiveness are included; extensive guidance is not.

D. LANL personnel only: This document does not reduce any program- or administrative-type requirements applicable to LANL in the LANL Standards (ESM examples: Building Code Program, Welding/NDE, Commissioning, and Pressure Safety, including project engineer actions, owner and AHJ reviews and inspections; LANL Master Specifications examples: STR notifications to authorities and inspectors). Furthermore, ESM Section Z10 statements on applicability of LANL Standards to non-facility situations also applies.

## 2.0 DEFINITIONS AND ABBREVIATIONS

Refer to Conduct of Engineering Glossary for definitions and abbreviations used in this document and its references.

## 3.0 CONVENTIONS IN THIS DOCUMENT

A. This document includes minimal guidance; italics (or a clear heading) indicates such. Reference titles are also italics

B. Reference to chapters is generally to TSM chapters; if to the ESM, they will so note.

C. LANL Only: In the LANL-only TSM version on the TSM webpage, “(Requirement T-[Chapter No.]XYZ)” appears throughout. A spreadsheet available with that version provides the basis for the corresponding material.

## 4.0 DOCUMENTS IMPLEMENTED

See Appendix A for a listing of DOE/NNSA mandates and codes and standards for which following the TSM should ensure compliance.

## 5.0 CODES AND STANDARDS

A. Comply with the requirements of construction defined by the applicable Code(s) of Record (CoR) as defined by the project Scope of Work (SoW), including Functions & Requirements or Requirements & Criteria type-documents.

B. Comply with all relevant (applicable) voluntary consensus and industry codes and standards (code-invoked editions, and latest when otherwise). See also TSM Ch. 16 regarding building-type codes.

C. Submit listing of design codes and major standards by edition committing to follow for LANL review and approval no later than the 30% design maturity point (sooner is better).

D. Where conflicts between codes arise but are not addressed herein, the more stringent requirement shall apply, unless otherwise directed by the LANL Authority (AHJ/SMPO).

E. Deviation from this TSM document requires LANL Responsible Manager approval; contact applicable POC to discuss approaches.

## 6.0 SITE SPECIFICS (MULTI-DISCIPLINE)

A. Elevation

1. Nominal = 7,500 ft

2. Range = 6,250 – 7,780 ft (depending on specific location)

B. Latitude: 35.9 deg N, Longitude 106.3 deg W

C. Barometric Pressure (avg): 11.10 psia (22.65 inches Hg).

D. Air Density (7,500 feet): I-P: 0.057 pounds/cubic foot (0.075 pcf at standard air)

1. S-I: 0.00091 g/cm$^3$ (0.0012 at standard air/sea level)

E. Air Density Ratio: 0.075/0.057 = 1.32 (reciprocal = 0.76)

*Note: Exceptions to the above (where elevation or other data must be corrected to actual for remote sites) are contained in ESM Chapter 1 Section Z10.*

## 7.0 COMPLETE DESIGN

A. The design agency is responsible for a complete, coordinated design package; this includes but is not limited to:

1. Drawings or sketches (a) consistent with calculation results, (b) consistent with other discipline drawings, and (c) that are coordinated with the Specifications.

a. Designs documenting final design inputs (including IEBC Alt Level if applicable) and fire ratings of any walls being penetrated.

b. Drawings, when required, produced per the *LANL CAD Standards Manual*, STD-342-300, unless a LANL CoE-approved alternative is included in the SoW.

c. Building Information Modeling (BIM) to be compliant with LANL CAD Standards Section 400 BIM Standards.

d. A CSI-format specification book must be created for the project by combining multiple specification sections (exceptions for very small projects as allowed by ESM Z10 Att. F).

B. Design package shall be clear, concise, complete, and correct construction documents in accordance with the industry standard of care; including specifying products with availability that supports the project schedule; without repetition or conflict internally nor with construction subcontract pro forma (general conditions, etc.) and meeting all imposed and derived design inputs (and any approved changes).

C. Design Agency must perform required internal checking and verification reviews in accordance with their Quality Assurance (QA) plan prior to submitting to LANL reviewers. Externally produced design will be reviewed by LANL in accordance with AP-341-620, *Review and Verification of Design Documents* or equivalent; Design Agency must resolve comments to satisfy that Administrative Procedure (AP).

D. Design Agency must provide detailed documentation of how they implemented each requirement in their scope of work and that the requirement has been met in the design.

E. Submit design deliverables per review schedule provided by LANL; where not explicitly stated in the SoW, default to that prescribed by ESM Ch. 1 Section Z10 Att. C, *Design Deliverable Schedule 30-60-90-100%*. As a minimum, projects subject to the Ch. 16 Building Code Program require a satisfactory final "Plan review." The 90% review is LANL's building permit review, consisting of comment resolution and final back check of the 100% submission.

## 8.0 PROJECT FILES — GENERAL

A. Produce and deliver electronic files that include all information important to the accomplishment of the design for the entire lifecycle of the design, procurement, and construction, testing/startup, and commissioning.

B. Electronic files shall have optical character recognition (OCR) functionality which allows content searching. Submit non-electronic deliverables only when electronic is impossible (e.g., samples, mockups, prototypes, spare parts).

C. Document design by a set of calculations, drawings and/or sketches, and design/evaluation criteria commensurate with project scope that demonstrate the design is both safe and cost effective. When the design is complete, there must be a historical record showing how the design progressed and reasons for changes.

D. The project file shall include design review records, submittals, changes, and test and inspection results. It should also include significant written correspondence, summary of significant telephone calls, design and design-evaluation criteria whether furnished by LANL or designer-generated and working notes.

E. The Design Agency is responsible for producing and delivering the complete project file as described above; however, when LANL directs the use of LANL document review and/or control tools or services to (1) manage selected reviews (e.g., of submittals) or (2) maintain official versions of drawings, documents, and/or records, the Design Agency need not maintain duplicative records of these records—and shall not deliver same (to prevent duplication/confusion). See also Project Closeout topic at end of this chapter.

## 9.0 CALCULATIONS

A. Prepare design calculations to document analytical determinations in accordance with the Design Agency's processes. Room numbers, equipment nomenclature, fixture numbers, zone numbers, or any other designations must be consistent with those indicated on the drawings or in the specifications. Calculations must be checked, reviewed, sealed when required, signed, and dated by the designer and the checker, complete in all respects and must reflect the basis for selection of systems and components.

B. Calculations shall be performed, numbered, and approved in a consistent format and shall include, at a minimum, sections for Purpose, Methodology, Acceptance

Criteria, Unverified Assumptions, Assumptions, Limitations, Calculation Inputs, Computer Hardware and Software, Summary and Conclusions, References, and Calculations. Include notes/comments that strengthen the design coherence and communicate intent. Note references (source) for unusual formulas or methods of analysis, including edition of the reference and page number. Clearly label all variables and constants with the appropriate engineering units. Provide copies of tabulated data used.

C. For Design Agents who do not have a calculation format that supports the key attributes in the two paras above and would thus be acceptable to LANL, calculations must be prepared in accordance with LANL AP-341-605, *Calculations* or LANL-approved alternative.

D. Neatly arrange sketches, input, output, and other material pertinent to the analysis, use 8½ × 11-inch sheets where practical, and include in the complete analysis presentation.

E. Submit calculations to LANL for review and acceptance as requested or required. This approval does not relieve the designer of any responsibility for correctness and coordination with the drawings and specifications.

F. Calculations must be printed clearly and with sufficient darkness and contrast to ensure clarity. Index calculations in a logical order and include adequate sketches to allow others to follow and comprehend them easily.

## 10.0 PROJECT DOCUMENT LIST (PDL)

A. Project Document List (PDL): Unless waived by LANL (e.g., Integrated Project Team/IPT), the Design Agency shall produce and deliver an index of all project drawings, calculations, trade study reports, and other documents during the project and finalizing at close-out.

*Guidance: Include design outputs and other deliverables (including revision and date). Projects using LANL's design review tool may employ other means to accomplish document control (and transfer-to-EDRMS functions).*

## 11.0 PROFESSIONAL ENGINEER SEALING (STAMPING)

A. Outputs prepared by non-LANL engineers, consultants, and contractors (i.e., Subcontractors) that are involved in the practice of engineering must bear the seal (stamp) and signature of a professional engineer (PE), currently licensed in New Mexico, in responsible charge and directly responsible for the engineering work.

B. PEs shall only practice and seal for those disciplines for which they have qualified as a competency with the NM Licensure Board (which may be reflect on their website in the future). LANL engineering group leaders and above may waive this requirement based on significant demonstrated experience and competency (via variance or memo to project file).

C. Clarifications and exceptions in ESM Ch. 1 Z10 allowed.

## 12.0 EQUIPMENT LOCATION/DESIGN

A. Maintenance: Active mechanical, electrical, controls, and similar equipment must be accessible for inspection, service, repair, and replacement without demolition (removing permanent construction) or necessitating abnormal or unsafe action (e.g., crawling on ducts, piping, conduit, or cable trays). Equipment that contains electrical components that must be serviced must have NEC-specified (§110) working space.

B. Outside: Select sites carefully when locating equipment on grade. Ensure that factors such as snow accumulation and drift, ice, windy areas, rainwater from roof overhangs, etc., do not affect equipment performance and maintenance. *Avoid locations on the north side of the building.*

C. Roofs: Locate equipment a minimum of 10 feet from the edge of roof or inside face of parapet whenever practicable. If the distance is less than 10 feet, provide a 42-inch-high restraint (e.g., guard rails, parapet, screen wall), to provide fall prevention.

## 13.0 ITEM NUMBERING AND LABELING; PROJECT EQUIPMENT LIST (PEL)

A. Projects must develop an equipment/component listing as a turnover document. LANL transforms the PEL to the Master Equipment List (MEL) for the operating facility.

B. Design Agency shall initiate the PEL. PELs must follow applicable ESM Chapter 1 Section 200 – *Master Equipment List; Item Numbering and Labeling* requirements (include all required Structures Systems, and Components (SSCs), mandated item naming/labeling syntax and names & acronyms for systems and items, use of Upload Workbook, data, etc.) so that PEL-to-MEL manipulation and upload to the computerized maintenance management system (CMMS) is seamless. Coordinate with LANL Facility Design Authority Representative (FDAR) and MSS-CMMS personnel to ensure accuracy of PEL. PEL shall include all items specified by the design with fields populated with all information known at the point of final design completion.

C. The Constructor, unless otherwise stated in the Subcontract Documents, is responsible for populating the remainder of the Design Agency-created PEL workbook (Attachment 1: CMMS Upload Workbook [xls]) with the actual SSCs (make/model, etc.) selected [and, where applicable, accepted via Engineer of Record (EOR) review of submittals in the Specifications]. Next, coordinate with LANL FDAR, Facility Operation Director (FOD), and MSS-CMMS personnel to ensure accuracy and final approval of all labeling. Once complete, provide the PEL as a submittal to the EOR who shall review and deliver as a project record document. The LANL FDAR or designee will ensure worksheet upload into CMMS MEL.

## 14.0 LANL MASTER SPECIFICATIONS AND DETAILS

A. LANL Master Specifications (LMS) in the STD-342-200 collection are templates contain materials, methods, and quality related content specific to LANL. Projects shall meet their requirements (1) only where a given Section or Sections is

invoked specifically herein or (2) when a product within one is indicated as "no substitution." LANL in-house design shall meet the requirements of all applicable sections. When used, LMS templates must be tailored and edited for the project within the boundaries established by ESM Ch. 1 Section Z10 Attachment F.

B. Standard Details (templates for CAD) are also available in the STD-342-400 collection and have the same expectations as for LMS above. In the same collection, Example Drawings and Designs illustrate acceptable content, format, and professionalism (with additional types addressed by Section 300 of the CAD Standards Manual/CSM).

C. Specifications (Div 01)

1. Design shall require compliance with the provisions of the following LANL Master Specifications (online here) — or Chapter 1 POC-permitted commercial versions of same where applicable — and others in Div 01 and other divisions where invoked by other chapters:

| Section | Title |
|---|---|
| 01 1117 | Work by Owner–Self Perform[4] |
| 01 2500 | Substitution Procedures |
| 01 3300 | Submittal Procedures[5] |
| 01 3545 | Water Discharge Requirements |
| 01 4000 | Quality Requirements – Non-nuclear |
| 01 4216 | Definitions |
| 01 5705 | Temporary Controls and Compliance Requirements |
| 01 6000 | Product Requirements |
| 01 7700 | Closeout Procedures |
| 01 7823 | Operation and Maintenance Data |
| 01 7839 | Project Record Documents |
| 01 8113.13 | Sustainable Design |
| 01 8734 | Seismic Qualification of Nonstructural Components (IBC) |

## 15.0 PROJECT CLOSEOUT

A. Final project record documents shall include the incorporation of approved interim changes (e.g., field change requests (FCRs) design revision notices (DRNs), redlining as allowed, and discovered differences (e.g., from walkdowns) in the native software (e.g., AutoCAD or Revit) and in PDF, and signed by Design

[4]For subcontracted projects, only needed when LANL craft will do some physical work described in the Specification (e.g., tie-ins).
[5] Interpret LMS 01 3300 statement "all submittals required by all the LANL Master Specifications" to mean only those required by this TSM document plus those used electively by Project.

Agency. Ref. LANL Master Spec Section 01 7839, *Project Record Documents*. *Design Agency encouraged to walk down the work.*

1. For calculations, Design Agency shall as built/finalize those that contained non-bounding (non-conservative) assumptions and provide matrix tabulating how such assumptions were verified.
2. Interim change (e.g., redline, FCR) incorporation is not necessary for: demolition plans that become moot; vendor data; QA records; informal isometric sketches for piping installation; temporary bracing plans for formwork or erection.

B. As-built (A-B) drawings: These are a subset of project record documents. A-B drawings (and any data in a Record BIM that generates them) accurately reflect the final condition ascertained by LANL walk down and formal discrepancy resolution and are only produced for the most critical documents. LANL will utilize record drawing/model drafts (produced per direction above), walk them down, and deliver any additional changes to Design Agency or other Final Document Creator shown in Table 1-1 to produce the as-built. *Design Agency also encouraged to walk down the work*.

1. When "Final Document Creator" incorporates redlines from Verifier walkdown and add "as-built with (or without) changes" — and by whom verified — to the document record of revision, provide to LANL for review, and re-issue. (ref. CAD Std Manual Section 100 for details).

*Guidance: LANL A-B walkdowns are appropriate for "Priority" and "Support" documents that are necessary for safe operation. Most are captured by the categories shown in the table below. (This is generally only a handful of drawings).*

Table 1-1. LANL Roles in As-Builts, by Doc Category

| Doc Category | Doc Types | Typical LANL Verifier | Final Doc Creator |
|---|---|---|---|
| Where Final Document Creator is Typically Not LANL | | | |
| Building automation system (non-nuclear facility HVAC) | Shop drawings, programming | I&C engineering or delegate | Constructor (e.g., delegated design/build sub tier) |
| Fire protection<br>1. Fire area boundary drawings<br>2. Fire barrier penetrations database<br>3. Fire suppression P&IDs, details and schedules, and sequence of operation / I&C Diagrams<br>4. Sprinkler system hydraulic calculation(s)<br>5. Location drawings of underground water mains and control valves, hydrants, and fire department connections | Calcs, drawings, shop drawings, specs, FACP programming | Field Eng, Building Insp, or ES-FP per FP Div. of Responsibility | Constructor (e.g., delegated design/build sub tier) |

| Doc Category | Doc Types | Typical LANL Verifier | Final Doc Creator |
|---|---|---|---|
| 6. Fire alarm system diagrams and programming | | | |
| System and Facility Design Descriptions | SDDs, FDD | System Engineer or others | Author of latest approved version (Design Agency is default) |
| All other documents specifically required to be A-B by FDAR and not shown above, typically including P&IDs, electrical one-lines and panel schedules, and certain other *Priority* or *Support* documents. | Drawings, specs | Field Engineer or Building Inspector | Design Agency[6] |
| Categories where LANL Performs all Roles | | | |
| Floor Plan of Record (FPR) | Drawing per ESM Ch. 4 B-C GEN and CAD Standards Manual | MSS-DATA | |
| Emergency Evacuation Diagram (where required; based on FPR) | EED | EM (normally delegated to ES) | |

C. At the completion of facility projects, transmit drawings, specifications, and other project records to LANL Document Control (*SI-DCRM*) in accordance with the expectations of LANL Master Specifications Section 01 7839, *Project Record Documents* (or project-specific spec section with equivalent requirements).

1. For drawings, follow additional requirements for transmittal in the LANL CAD Standards Manual.
2. Also, if imposed by the Subcontract, follow any LANL project management procedures (*internal link*) on commissioning, turnover, acceptance, and closeout.
3. In addition to any hardcopy requirements, transmit all submittals electronically in native format (e.g., Word, AutoCAD, etc.) when that is available (pdf otherwise). PDF OCR requirements under Project Files heading above also apply here.
4. For Record BIM, follow additional requirements for transmittal in the *LANL CAD Standards Manual* Section 400 – *BIM Standards*.

[6] If differences between design and execution are discovered by a walkdown, then PE seal is normally required indicating PE acceptance of final configuration.

# Chapter 2 FIRE

## 1.0 CONSENSUS CODES AND STANDARDS

A. Follow requirements of Chapter 1, *General*; Chapter 16, *Building Code Program*; and codes and standards referenced therein.

B. Comply with IBC-2021 and all applicable NFPA codes and standards including the following editions*:

- International Fire Code (IFC) – 2021 Edition, including Appendix B
- NFPA 1, *Fire Code* – 2021 Edition
- NFPA 101, *Life Safety Code* – 2021 Edition

* The applicable codes and standards will not be limited to those in this list. Refer to the above-adopted codes to determine appropriate referenced standards and editions and submit for LANL approval. LANL requires compliance with the requirements of applicable NFPA standards in addition to IBC and IFC requirements.

- NFPA 90A requirements apply in lieu of those of the IBC and Uniform Mechanical Code (UMC) regarding fire protection of air-conditioning and ventilating systems.
- The 2021 editions of the UMC and UPC reference NFPA 54-2018 and NFPA 58-2017, but NFPA 1-2021 references NFPA 54-2021, and both NFPA 1-2021 and IBC-2021 reference NFPA 58-2020. Per VAR-10545 adopting the older editions, “Guidance: Newer editions [of NFPA 54 and NFPA 58] should be used if doing so will not conflict with direction in (intent of) the UMC or UPC.” Where there is a conflict, these earlier editions may be used unless the IBC, IFC, or NFPA 1 also reference NFPA 54 or NFPA 58 for a similar requirement.

C. This document does not document all possible requirements and criteria for projects, including when to provide automatic sprinklers. The designer is responsible for reviewing and implementing the requirements of applicable codes and standards.

D. Where multiple codes and standards overlap, comply with the most stringent unless dictated otherwise by LANL Engineering Services – Fire Protection Engineering (ES-FPE).

## 2.0 AUTHORITY HAVING JURISDICTION

A. The LANL Fire Marshal serves as the technical authority for fire protection and life-safety related DOE Orders, and codes and standards as assigned by the DOE/NNSA Los Alamos Field Office.

B. Where codes and standards refer to the Fire Code Official (as in the IFC) or Authority Having Jurisdiction (as in NFPA codes and standards), it is the LANL Fire Marshal.

C. Engineering Services – Fire Protection Engineering (ES-FPE) serves as the LANL Fire Marshal designee as assigned by the LANL Fire Marshal.

D. ES-FPE determines the level of fire protection required for LANL facilities and projects with respect to highly protected risk (HPR) criteria. Replacement value, mission importance, and other factors provided by the project may lead to a determination that this TSM is not applicable, and that the HPR criteria invoked by the full LANL Engineering Standards Manual (ESM) are applicable.

E. The design of fire department access roadways; marking of fire lanes; locations of fire department connections (FDCs) and test headers; location of fire alarm control panels; location of riser/pump rooms; type of sprinkler, extinguishing, and standpipe systems; and other emergency functions and fire protection systems are subject to LANL Fire Marshal approval.

## 3.0 DESIGN AND DESIGN DOCUMENTATION

Developing an effective fire protection design and maintaining an effective fire protection program at a new or modified facility requires consideration of a variety of fire protection topics at an early stage of any project, and oversight by a qualified fire protection engineer. *These considerations should be continually revisited throughout the project with increasing attention to detail until the project is completed.*

A. Fire protection features may include, but are not limited to:

1. Fire department access roadways, physical access, and equipment for fire department intervention.
2. Water supply and distribution for manual firefighting and fire suppression.
3. Life safety and means of egress features.
4. Fire-resistance rated construction and barriers to isolate hazards, protect vertical openings, and maintain availability of the means of egress.
5. Automatic sprinkler systems design and installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, and as modified within this Section.
6. Standpipe systems in accordance with NFPA 14, Standard for the Installation of Standpipe and Hose Systems, where required by the IFC, NFPA 101 or where necessary to protect areas where laying of hose lines is problematic because of ventilation, security, or other reasons.
7. Fire detection and alarm systems in accordance with NFPA 72, National Fire Alarm and Signaling Code, and as modified within this Section.
8. Special fire extinguishing systems for unique hazards or occupancies in accordance with the applicable NFPA standard.

B. Prepare a fire protection design analysis (FPDA) when required by subsection below to document compliance with the applicable fire protection and life safety requirements and criteria.

1. An FPDA is required where any of the following conditions exist:
   a. New facilities exceeding 5,000 sq ft of floor area or a maximum possible fire loss (MPFL) exceeding $5.9 million (in 2018 dollars)[7],
   b. Where a modification to an existing facility:
      i. Increases floor area above 5,000 sq ft,
      ii. Increases MPFL above $5.9 million (in 2018 dollars),
      iii. Is classified as an IEBC Level 3 Alteration,
      iv. Includes an addition greater than 1,500 sq ft, or
      v. Includes a change in occupancy to a higher hazard category of occupancy when greater than 1,500 sq ft.
   c. New facilities or modifications introducing unusual or significant life safety hazards,
   d. New facilities or modifications introducing high hazard contents, processes, and occupancies (e.g., Group H occupancy classifications, flammable liquid dipping operations, or high-pile storage areas greater than 500 sq ft), or
   e. Where directed by ES-FPE.
2. The FPDA shall be prepared by a fire protection engineer.
3. Prepare the FPDA early in the preliminary or conceptual design phase and provide no later than 30% design maturity/review.
4. Discuss the following minimum fire protection provisions (both as-required and as-provided characteristics):
   a. Building code analysis (i.e., type of construction, height and area limitations, and building separation or exposure protection).
   b. Classification of occupancy and alteration/work category.
   c. If applicable, analysis of highly-protected-risk (HPR) criteria and other risk guidelines that must be applied.
   d. Requirements for fire-rated walls, fire-rated doors, fire dampers with their fire-resistive ratings, smoke compartmentation, smoke barriers.
   e. Means of egress in accordance with NFPA 101, *Life Safety Code* and the IBC (occupant loads, exit capacities, etc.).
   f. Analysis of automatic sprinkler systems and other suppression systems and protected areas, including hydraulic analysis of required water demand.

[7] See TSM Attachment 1 for escalations to present day.

g. Water supplies, water distribution, location of fire hydrants, including hydraulic analysis of the required water supply and manual fire flow.

h. Smoke control methods and smoke control systems.

i. Fire alarm system (the type of alarm system and location of major equipment).

j. Fire detection system (the type of detection system and coverage areas).

k. Standpipe systems and fire extinguishers.

l. Interior finish ratings and materials of construction.

m. Connection to and description of fire alarm supervising system.

n. Identify the various occupancies and hazardous areas associated with the facility.

o. Coordination with security requirements.

p. Fire department access.

q. Draft analysis of unresolvable deficiencies or code conflicts (IBC versus NFPA), variances, or alternate methods requiring a request for relief (NNSA Field Office disposition, or equivalency or exemption request).

C. Meet the requirements of the following LANL Master Specification sections, modified appropriately for the project.

1. Those in Division 21 for the type of sprinkler system to be installed.

2. Section 28 4600 for fire alarm system installations. Exception: where EMT raceways are used, fittings shall not be required to be compression type.

D. Provide calculations per the applicable NFPA standard to support the fire protection design, including but not limited to:

1. Water supply analysis and hydraulic calculations to determine available and adequate water supply and distribution for firefighting and fire suppression.

2. Preliminary and detailed hydraulic calculations for automatic sprinkler systems and other fire suppression systems.

3. Occupant load and egress capacity calculations.

4. For fire alarm systems, battery load, voltage drop, and line resistance calculations.

5. Supporting calculations for special hazard, smoke removal, and other fire protection systems.

E. Provide drawings to support the fire protection detailed design (shop drawings), including but not limited to:

1. Code analysis, including occupancy/hazard classification, level of alteration/rehabilitation, height and area, fire-resistance rating, means of egress, sprinkler and suppression, fire alarm and detection, vertical openings, opening protectives, fire exposures and fire separation distance, and other relevant details.
2. Life safety drawings detailing occupancy classification, occupant loads, egress capacity, travel distances, areas of emergency lighting coverage, fire and smoke barriers and partitions, opening protectives, firestopping, fire-resistant joints, fire extinguishers, and other relevant details.
3. Site compliance plans detailing fire department access roadways, fire lane marking, fire department connections, Knox boxes, hydrant and post indicator valve location and spacing, hose pull lengths from hydrants and roadways around building perimeter, and other relevant details.
4. Fire protection drawings detailing the fire suppression (sprinkler) system, performance requirements, preliminary plans, and supporting information and analyses for the detailed design (i.e., shop drawings), which is typically delegated and deferred. Detailed designs (i.e., shop drawings) shall comply with NFPA 13.
5. Fire alarm drawings detailing the fire alarm and fire detection system, preliminary plans, performance requirements, and supporting information and analyses for the detailed design (i.e., shop drawings), which is typically delegated and deferred. Detailed designs shall comply with NFPA 72 requirements for design documentation, shop drawings, and record of completion documentation.
6. Other documentation as required for special hazards and systems, non-standard conditions, alternative means of compliance, etc. to support the fire protection design.

F. Fire sprinkler and fire alarm system detailed designs (shop drawings) shall be prepared by NICET-certified technicians in Fire Alarm Systems or Water-Based Systems Layout (Level III or Level IV), unless approved otherwise by the LANL Fire Marshal.

G. Guidance: Fire protection and life safety features, devices, and criteria should be included in all other discipline drawings to clearly demonstrate compliance and coordinate different structures, systems, components, and trades.

## 4.0 BUILDING CONSTRUCTION

A. Construction type shall be noncombustible, at a minimum IBC Type II-B / NFPA 220 Type II (000). Exception: Buildings under 5,000 square feet with LANL ES-FPE approval.

B. Roof coverings shall be IBC Class A.

C. Fire barriers shall be provided to protect vertical openings, the means of egress, separate occupancies, create control areas, limit property loss to $412 million (in

2018 dollars)[8] per fire area, protect from exposure hazards, and separate hazardous areas; as required by the IBC/IFC, NFPA 101, and other applicable codes and standards.

D. Fire-resistance and smoke leakage rated assemblies (e.g., fire walls, barriers, and partitions) and smoke barriers and partitions shall be labeled above removable ceilings; below raised floors; and in mechanical, electrical, and similar spaces not normally occupied.

E. Openings, penetrations, and joints in fire-resistance and smoke-leakage resistance assemblies shall be protected with an appropriate listed assembly or system to maintain continuity and the rating. Obtain engineering judgments for configurations and conditions for which no listed assembly or system exists. Alternative means of firestopping provided in the IBC, and NFPA codes and standards are permitted.

F. Comply with NFPA 1144*, Standard for Reducing Structure Ignition Hazards from Wildland Fire*. As a minimum, a 10-foot-wide space around buildings shall be maintained clear of all trees. In more heavily forested areas, a 50-foot-wide space around buildings shall be maintained clear of trees (several isolated trees may be acceptable), and the next 50 feet beyond shall be thinned. In less heavily forested areas, less clearing/thinning may be acceptable. Consult LANL Fire Marshal for guidance.

## 5.0 FIRE WATER SUPPLY AND FIRE SERVICE FEATURES

A. Fire protection water supply distribution systems and associated appurtenances shall comply with NFPA 24. Combined fire protection and potable/domestic water supply distribution systems shall also comply with the applicable TSM Ch.3 requirements.

B. Fire protection water supplies shall be designed to provide minimum manual fire flow, as required by NFPA 1 and IFC Appendix B, and the most demanding fire suppression flow and pressure, non-concurrently.

C. Fire protection water service from a combined water supply source shall enter the building and be controlled separately from potable/domestic water.

D. Fire hydrants, fire department connections, test headers, hose valves, and similar hose connections shall be National Hose (NH) thread.

E. Fire hydrants shall:

1. Be provided to meet spacing and fire flow demands in accordance with the IFC and NFPA 1;

2. Be three-way with two 2-1/2” diameter outlets and one 4-1/2” diameter outlet;

[8] See TSM Attachment 1 for escalations to present day.

3. Be no closer than 40 feet from the facility's exterior walls;
4. Be provided in number at minimum two to a building;
5. Be located such that hose runs from hydrants do not exceed 300 feet to all exterior portions of the facility;
6. Be provided (at least one) not more than 150 feet from the fire department connection; and
7. Be on branch line not more than 300 feet long.

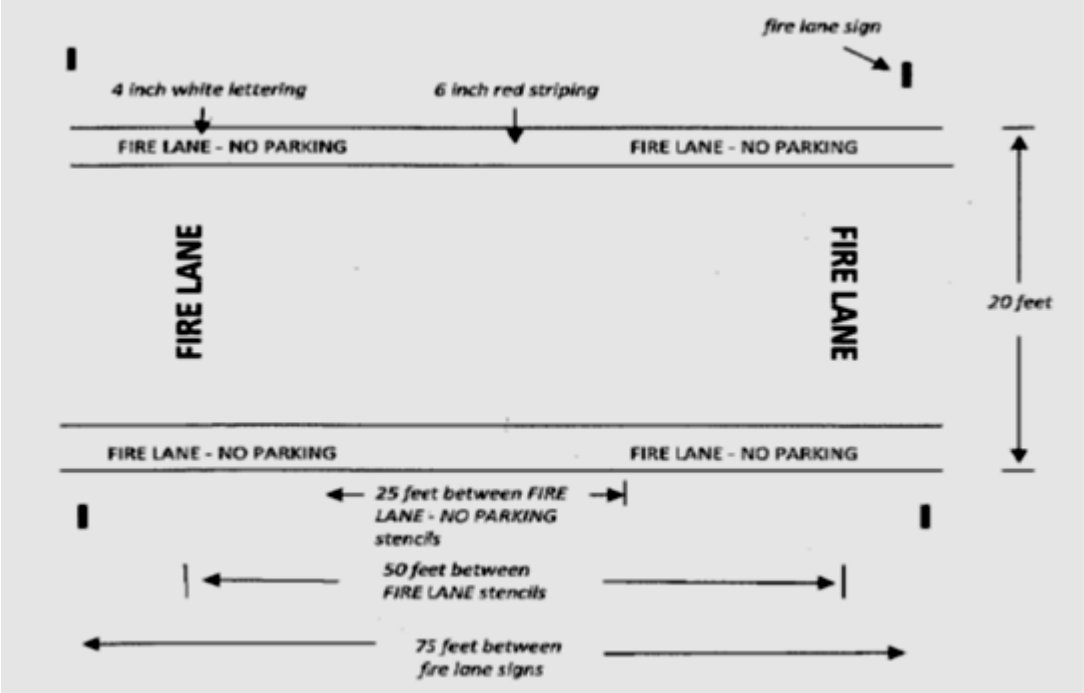
F. Fire department access roads shall:

1. Have a minimum inside turning radius of 30 feet, a minimum outside turning radius of 50 feet, and support a fire apparatus with a total weight of 83,500 pounds and an axle weight of 63,000 pounds.
2. Be a paved, all-weather surface, unless approved otherwise by the LANL Fire Marshal.
3. Be marked as fire lanes within vehicle parking lots, along alleys or roadways that are not designated or marked as a LANL street or road, within 15 feet of a fire hydrant or fire department connection; and other locations where required by the LANL Fire Marshal.

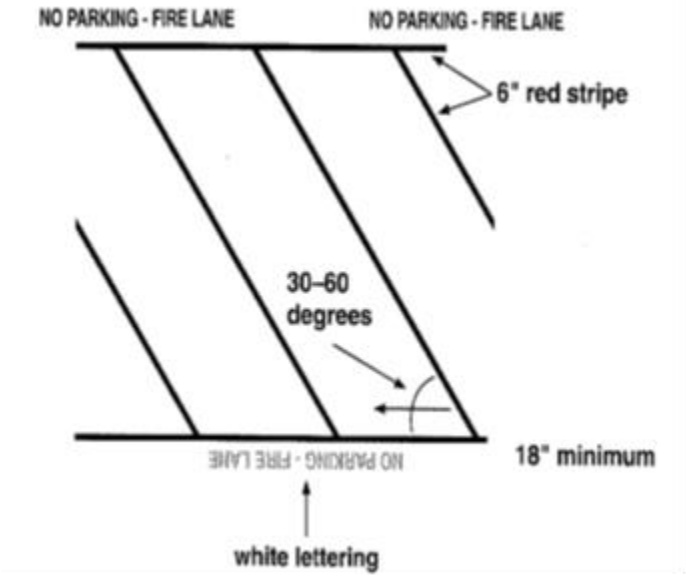
G. Fire lanes shall be marked on both sides – unless permitted otherwise – with signs, curb markings, road surface markings, or a combination thereof as follows:

1. Signs shall be metal construction, 12 inches wide by 18 inches high, reflective, with red lettering on a white background. Signs shall read one of the following:
   a. FIRE LANE – NO PARKING
   b. NO PARKING – FIRE LANE
2. Signs shall be mounted 7 feet above the road surface, at both ends of the fire lane, and at a maximum 50-foot interval. The interval may be increased to 75 feet when combined with curb or roadway markings.
3. Curbs shall be painted red along the entire length with "FIRE LANE – NO PARKING" in 4-inch high, white letters at a 25-foot maximum interval.
4. Road surface markings shall consist of "FIRE LANE – NO PARKING" in 4-inch, white letters inside the stripe at a 25-foot-maximum interval along the edge of the road. This shall be supplemented either:

   Option 1: 6-inch-wide red stripes along the edges of the roadway and collinear with the letters. In the roadway "FIRE LANE" in 10-inch high, red or white letters marked at 50-foot intervals, and oriented to be read from the direction of fire department arrival as shown immediately below.




Option 2: Letters along edges of the roadway and outlined, diagonal hatching in the roadway between. The outlined, hatching consists of 6-inch red stripes along the edges of the road and diagonal stripes between the edges at 18-inch spacing and angle between 30 and 60 degrees as shown below.




## 6.0 AUTOMATIC SPRINKLERS, STANDPIPES, AND OTHER WATER-BASED SYSTEMS

A. Automatic sprinklers shall be provided when required by the applicable codes and standards, and for all facilities greater than $5.9M (in 2018 dollars) in maximum possible fire loss (MPFL) or 5,000 square feet in area. The LANL Fire

Marshal may require a fire suppression system when warranted by significant life safety hazards or other concerns.

B. Design:

1. All systems shall be hydraulically designed.
2. Use of Light Hazard occupancy protection criteria requires LANL pre-approval, including a determination agreeing that the use or occupancy of the facility will not change in the future.
3. Provide a minimum hose stream allowance of 250 gpm, unless NFPA 13 specifies a greater quantity for the specified protected hazard or occupancy.
4. Hydraulic calculations shall include a design pressure margin of 10% or 10 psi, whichever is greater.
5. For sprinkler system seismic bracing calculations, use a seismic coefficient, $C_p$, of 0.52; except for TA-50/55 where 0.42 may be used if desired.
6. The classification of the standpipe system and proposed configuration shall be approved by ES-FPE in consultation with the Los Alamos Fire Department.
7. A hydrant flow test can be requested via a LANL Facility Service Request for Utilities and Infrastructure (UI) and ES-FPE.

C. Detailed design drawings (e.g., shop drawings, installation drawings), shall be prepared by a fire protection technician, at a minimum, NICET Level III certified in Water-Based Systems Layout.

D. Title II (i.e., architectural-engineering preceding construction start) design drawings for automatic sprinkler and other water-based systems shall, at a minimum, include:

1. Types of automatic sprinkler, standpipe, and other systems to be provided.
2. Hazard classification, commodity classification, discharge density, and other performance criteria of the systems.
3. Fire water service, system riser, control valve, test header, and fire department connection locations.
4. Preliminary system design at hydraulically remote locations, with risers and mains to support preliminary hydraulic calculations.
5. Locations exempt from fire sprinkler coverage.
6. Exterior areas to be provided with fire sprinklers.
7. Means of freeze protection, when required.
8. Interfaces with other systems (e.g., fire alarm).

9. Ceiling elevations and ceiling features, structural members, large ducts, unit heaters, skylights, and other features potentially impacting the design of the sprinkler system.

E. Reduced-pressure backflow prevention is required for sprinkler risers when fire protection water supply is from a combined domestic and fire protection water supply systems. A drain shall be provided to direct nuisance flows to a sanitary floor drain and catastrophic releases to the exterior of the building.

F. For forward-flow testing of backflow preventers, provide a test valve header at an accessible location on the exterior of the facility.

G. Provide minimum clearances around system riser alarm valves of 12” rear, 20” sides, and 36” front.

H. The top of the alarm valve shall be no higher than 72” above the finished floor.

I. Provide dry-type sprinkler heads instead of dry-pipe or heat-tracing, whenever possible. Anti-freeze systems and subsystems shall not be installed.

J. Provide isolation valves on fire sprinkler supply lines serving elevator hoist ways, elevator machine rooms, computer rooms, and similar special protection areas. Electrically supervise isolation valves for automatic sprinkler, standpipe, and other suppression systems, including post indicator valves and alarm trim isolation valves. Provide waterflow switches for detached or remote portions of the facility, not accessible from the interior. Valves shall be accessible from the finished floor without use of a ladder or other equipment.

K. Sprinkler system air vents shall be vented to the exterior of buildings or sanitary drain, unless equipped with an automatic shutoff. An inspector’s test valve may be used with the approval of the LANL Fire Marshal.

L. LANL has standardized on manufacturer and model of fire suppression system monitoring devices and equipment for the purposes of life-cycle maintenance, spare parts management, and technician training and qualification, as follows.

1. Potter Model PS10 Pressure Waterflow Switch
2. Potter Model WFSP-F Pressure Activated Waterflow Alarm Switch with Retard
3. Potter PS40 High/Low Supervisory Air Switch
4. Potter BVS Supervised Ball Valve
5. Potter Electric Model VSR
6. Potter Model PAV Automatic Air Vent or Potter Model PAAR Automatic Air Vent with Drip Pan
7. FEBCO Mode LF880V Backflow Preventer or Wilkins Model 475V Backflow Preventer

## 7.0 FIRE ALARM AND DETECTION SYSTEMS

A. All facilities shall have a means to summon emergency services in the event of a fire or other emergency. Unless approved otherwise by the LANL Fire Marshal, at a minimum this shall be a manual fire alarm pull station. All fire alarm systems shall report to the LANL Proprietary Supervising Station via fire alarm control panel with a Digital Alarm Communication Transmitter (DACT). The DACT connected by three CAT 5E telecommunication cables that shall be run from the DACT location to the telecommunications service entrance room in the building.

B. Fire alarm systems and fire detection systems shall be provided when required by the applicable codes and standards. Fire alarm systems shall be provided when automatic sprinkler systems, or other fire protection systems or emergency control functions are provided, for monitoring and supervision.

C. Documentation shall be provided for fire alarm designs, installation, and testing. Comply with NFPA 72 requirements for design documentation, shop drawings, and completion documentation.

D. Detailed design drawings (i.e., shop drawings, installation drawings), shall be prepared by a fire protection technician, at a minimum, NICET Level III certified in Fire Alarm Systems.

E. Title II (i.e., performance and/or design) drawings for fire alarm shall, at a minimum, include the following features where applicable:

1. Fire alarm control panel, NAC panel, and annunciator locations.
2. HVAC control equipment/panels requiring equipment shutdown.
3. Fire/smoke or smoke dampers.
4. Fire doors with hold-open devices to be released in an alarm event.
5. Elevator interface.
6. Location of fire suppression isolation valves.
7. Any other emergency interfaces (e.g., lighting controller, door access control, etc.).
8. Ceiling height and features, structural members, proposed equipment and furniture layout, and other features impacting device layout.
9. One-line diagram showing schematic system configuration (e.g., fire alarm riser diagram).
10. Preliminary input/output sequence of operation matrix.

F. Fire alarm control panels and associated components shall be an addressable EST or Notifier model.

G. Locate the fire alarm control unit in a temperature and humidity-controlled area at the main entrance to the building.

H. Provide 20% spare capacity on notification appliance voltage drop calculations to allow for future system modification. Provide backup battery capacity equal to or greater than 24 hours of normal (standby) FACP operation plus 10 minutes (as opposed to 5 minutes per NFPA 72) of system operation in full alarm mode. Provide 50% spare backup battery capacity (as opposed to 25% per NFPA 72) within calculations.

I. Fire alarm control panels shall have an LED annunciator/switch card providing the ability to disable emergency control functions, individually, and notification appliances.

J. Provide surge suppression devices in fire alarm power, initiating device, and notification appliance circuits entering or leaving a facility (due to frequent lightning activity), as described within LANL Master Specification 28 4600. Surge suppression devices shall be readily accessible from the finished floor level.

K. Provide manual transfer switch and capability for hook-up of portable generator in the normal power circuit for fire alarm control panels and remote power supply panels, as described in LANL Master Specification 28 4600.

L. Provide a standard 125VAC receptacle within 6 ft of the FACP to support connection of a laptop computer for fire alarm testing and troubleshooting purposes.

M. Fire alarm systems shall include manual fire alarm initiation, occupant notification, emergency services notification, and supervision of suppression systems. Signaling line circuits (SLCs) shall be designed as Class A, B, or X as determined by the FPDA or other appropriate design documentation.

*Guidance: NAC and SLC circuits should be zoned to coincide with building outer walls, building fire or smoke compartment boundaries, floor separation, or other fire safety subdivisions. Zoning of circuits is subject to approval by the LANL Fire Marshal.*

N. Provide horns or speakers for audible signaling. Public mode signaling is required in all occupiable areas, except bathrooms provided with strobes, stairwells, and elevator cars, where private mode signaling is permitted. Average ambient sound pressure levels shall be documented for all areas, based on use, occupancy, HVAC design, equipment, and other factors.

O. Provide visual signaling in all public use and common areas (e.g., lobbies, restrooms, conference rooms, break areas, corridors, aisles), computer/server rooms, open offices will occupant loads of 10 or more, storage rooms over 500 square feet, mechanical equipment rooms and other locations with high ambient sound levels, and other locations specifically requested by LANL.

P. Interface the fire alarm system with emergency control functions for supervision, monitoring, and activation; including but not limited to elevator controls (per ASME A17.1 for Phase I and II operations), HVAC systems (per NFPA 75, 76, 90A, and others), fire doors and other opening protectives (per NFPA 80), lighting controllers or access control (per IBC and NFPA 101), and suppression system releasing/control panels.

# Chapter 3 CIVIL

## 1.0 GENERAL CIVIL REQUIREMENTS

A. Coordinate surveys with LANL U&I Utility Mapping Department.

B. Stormwater Compliance. Projects greater than one acre require NPDES permits.

C. Projects >5,000 sq. ft. must meet EISA Section 438 standards.

D. Conduct hydrologic analysis using industry standard methodologies such as the Rational Method, Technical Release 55, SWMM, and HEC methodology to compute peak flows from drainage areas and size drainage structures, designing for a 25-year return storm unless otherwise required.

1. For projects under EISA Section 438 jurisdiction, perform hydrologic analysis using latest VAR-10468 and contact ENV-CP for review and approval.

E. Submit a request for an excavation (EXID) permit prior to commencing with potholing or excavation activities.

1. Refer to OSH ISH-FSD-003 Potholing Procedure for all underground line potholing requirements.

F. Environmental Protection. Adhere to NEPA guidelines and implement measures to protect cultural and biological resources.

1. Submit a Project Activity Review (PAR) to identify any items that may fall under regulatory jurisdiction, including stormwater controls and Environmental Restoration requirements.

## 2.0 SITE PREPARATION

A. Earthwork. Minimize site disturbance, preserve vegetation, balance cut and fill volumes.

B. Grading.

1. Ensure drainage away from structures with a minimum slope of 0.5 ft. over 10 ft.

2. Natural soil slopes should not exceed a 2:1 ratio (2 horizontal to 1 vertical). Undisturbed volcanic tuff slopes should not exceed a 1:6 ratio (1 horizontal to 6 vertical).

3. Subgrade preparation: Treat the top 6–12 inches beneath foundations, slabs, and pavement by scarifying, moistening, and compacting to 95% density. Unsound areas must be replaced with structural backfill. Elevation tolerance is ±0.05 feet per 10 feet. Finish slopes may exceed 2:1 if recommended by a geotechnical engineer.

C. Compaction Standards. Compact to 95% of maximum density as determined to ASTM D1557; adjust based on soil type and use case.

1. If competent volcanic tuff is encountered, it is exempt from the 95% compaction requirement; only the fill above needs to meet the 95% compaction requirement, as determined by the EOR.

D. Sieve Analysis. Perform sieve analysis to classify soil gradation and verify suitable for compaction or fill material.

1. Engineered fill shall conform to ASTM D6913.
2. Basecourse aggregate shall conform to ASTM D4318, with ASTM D4718 in conjunction with ASTM D1557 if necessary.
3. Crushed stone shall conform to ASTM C33.
4. Trench bedding shall conform to ASTM D2321 or ASTM C33.
5. General fill shall conform to ASTM D2487 and ASTM D1557.

## 3.0 SITE IMPROVEMENTS

A. Concrete: Construct exterior sidewalks, curbs, gutters, curb ramps, utility pads, drive pads, and all other concrete structures with air-entrained concrete, f'c = 4000 psi.

B. Road Design.

1. Design, including temporary traffic control, shall conform to the following standards:
   a. AASHTO GDHS, A policy on Geometric Design of Highways and Streets.
   b. AASHTO GBF, Guide for developing Bicycle Facilities.
   c. AASHTO RSDG, *Roadside Design Guide*.
   d. ITE TEH, *Traffic Control Engineering Handbook* [Institute of Transportation Engineers, ite.org].
   e. MUTCD, *Manual on Uniform Traffic Control Devices*, latest edition (http://mutcd.fhwa.dot.gov.
2. Comply with New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction including their latest modifications (supplemental specifications and special provisions).
3. Roadway asphalt paving and parking lot paving shall consist of a minimum of 4 inches of plant-produced hot-mix asphalt (HMA) on top of a minimum of 8 inches of aggregate base course on prepared subbase.
4. Portland Cement Concrete Pavement: Use design criteria outlined in the NMDOT, Standard specifications in the structural design of Portland Cement concrete pavements.
5. Curb and Gutter. Provide a 6-inch barrier-type curb and gutter with a 1-1/2-inch gutter depth for all internal corridors, collectors, and roads within

LANL boundaries. Reverse outflow gutter requires approval from LANL ES-UI Group.

C. Accessibility. Conform to ABA and Public Right-of-Way Accessibility Guidelines (PROWAG) for compliant sidewalks, streets, crosswalks, curb ramps, pedestrian signals, on-street parking, and other components of the public right-of-way.

D. Landscaping. Use native vegetation and erosion control strategies to stabilize soils and minimize runoff.

## 4.0 SITE CIVIL/MECHANICAL UNDERGROUND SYSTEMS

A. Structures shall not be sited within 10 ft of an existing underground line, nor new lines routed within 10 feet of an existing structure. New lines to new buildings shall approach perpendicularly.[9]

B. Water Lines. Provide a minimum of 4 ft of cover for freeze protection except irrigation systems with automatic drain valves.

C. Cathodic Protection. Required for underground metallic piping; consult LANL Utilities Corrosion Specialist for specifications.

D. Working within five (5) feet of underground lines:

1. Whenever practical, underground lines shall be de-energized, isolated, and tagged out.
2. Do not use mechanical excavating equipment within 5 ft of marked, non-potholed underground line until authorized by PIC or designee.

E. Underground Line Clearances shall conform to the following standards for potable water, sanitary sewer, fire protection, and electrical:

1. American Water Works Association (AWWA),
2. Uniform Plumbing Code (IAMPO UPC),
3. The National Fire Protection Association (NFPA),
4. National Electrical Code (NEC),
5. National Electrical Safety Code (ANSI C2), and
6. Grounding of Industrial and Commercial Power Systems (IEEE 142)

F. For secure communication lines clearances, consult LANL Security (PS-1), Engineering and Security Services (NIE-ESS), and ESM Chapter 18 Secure Communications POC.

[9] Clearances: For LANL PE, on variance for this and line-to-line clearances, chapter POC and ES-UI FDAR approval suffices (N/A the FOD and SMPO).

G. Underground Piping Systems.

1. Use tracer wire, APWA color-coded identification tape, and thrust blocks; ensure all systems pass pressure testing.

2. Warning Tape: Use non-detectable plastic warning tape consisting of high visibility, APWA color-coded, continuously printed, inert fiber reinforced polyethylene for direct burial service.

H. Tracer Wire: #12 AWG copper clad steel, insulations of HDPE minimum 30 mil thickness rated for direct burial. Insulation color shall meet the APWA color code for buried utilities.

I. Metering: Follow ESM Ch. 14 Attachment 2 - Utility Metering Requirements.

J. Potable Water. Conform to IAMPO UPC, National Fire Protection Association (NFPA) standards, AWWA guidelines and EPA regulations.

1. Design distribution system to maintain a minimum residual pressure of 20 psi at ground elevation for a period not less than 2 hours; adhere to New Mexico Drinking Water Regulations.

K. Sanitary Sewer. Follow the IAMPO UPC; AWWA guidelines; and ASCE Publications 77– Design and Construction of Urban Stormwater Management Systems and 37–Design and Construction of Sanitary and Storm Sewers.

1. In areas with an office and industrial mix, the population of the contributing area should be determined and the design flows calculated to be 25 gallons per capita per day, minimum.

2. Curvilinear sewers are not recommended and must be approved by the LANL U&IF Group Wastewater system representative.

L. Manholes. Provide precast concrete manhole sections per ASTM C478, approved precast septic tanks per ASTM C1227, and approved fiberglass or HDPE septic/holding tanks as per the Drawings.

1. Provide castings conforming to ASTM A48/A48M, Class 30B.

M. Fire Protection Systems. Locate lines and hydrants in accordance with TSM Ch. 2 Fire.

N. Potable water and fire sprinkler water systems supply lead-ins shall not be run under building; risers shall be inside building within 3 ft of exterior wall.

O. Steam/Condensate.

1. Steam Piping: Piping systems above 15 psig, upstream of the first shutoff valve, must comply with ASME B31.1. Systems below 15 psig must comply with ASME B31.9 or B31.3.

   For new buildings in TA-3 using the site steam system, see TSM Ch. 6 *Mechanical*.

   Cast iron is not permitted.

2. Condensate Piping: Condensate piping outside of the building that returns to a central steam plant shall comply with ASME B31.1, *Power Piping*.

P. Natural Gas. Design natural gas service in accordance with 49 CFR 192, Transportation of Natural and Other Gas by Pipelines; Minimum Federal Safety Standards; and ASME B31.8, Gas Transmission and Distribution Piping Systems. See also TSM Chapter 17, Pressure Safety.

Q. Industrial Waste. Conceptual and final design for on-site treatment and disposal systems must be approved by LANL's Solid Waste Operations Group and the LANL UI Group. See TSM Ch. 6, *Mechanical*.

R. Process Liquid Waste. Refer to TSM Chapter 6, *Mechanical*.

# Chapter 4 ARCHITECTURAL

A. Architectural Design Philosophy

*Guidance: The vision for the physical development of the Laboratory is to create an exceptional work environment that supports its mission and attracts and retains the quality personnel needed to meet that mission. Adhering to a world-class working environment the Laboratory aims to revitalize and enhance its facilities and infrastructure, intending to improve and maintain the functionality, safety, security, appearance, and life-cycle efficiency of the built environment.*

1. To that end, LANL's basic development goals are fully described in the *Site & Architectural Design Principles*. This includes its Chapter V, *Guidelines for Architectural Design*, to support stylistic cohesiveness, building façade color and material consistency within the planning area in which the facility is located. *Projects may also refer to the "LANL Sustainable Design Guide," if available*.

B. Codes and Standards

1. Comply with those required by Chapter 1–General. In addition, follow:

   a. Architectural Barriers Act (ABA).[10]

   b. Follow Chapter 14, *Sustainable Design.*

C. Design deliverables: Prepare Life Safety Floor Plan identifying egress routes compliant with IBC Chapter 10 Means of Egress; code analysis compliant to IBC/IEBC; and NFPA 101, *Life Safety* Code, criteria, and requirements.

D. EIFS: The use of exterior insulation and finish systems is acceptable if the Design Agency incorporates adequate protection measures to protect the system from pedestrian damage and landscaping maintenance up to a height of 7 feet above grade. Terminate above grade with J-bead. *Where practical, protect EIFS from the elements by projections (e.g., canopies, verandas, cantilevered stories above, etc.)*.

E. Elevators and other lifts: The Design Agency of record (EOR) is responsible for determining the appropriate type of elevator for the project. *The requirements and scoping documents should not specify the elevator type unless there are unusual circumstances that warrant LANL as a necessity for the owner and institution, such as requiring a freight elevator.*

1. Design to meet ASME A17.1, IBC (including Chapter 30 and A117.1), and NFPA 70.

2. Cab size shall follow code requirements unless user needs warrant larger; flooring must meet radiant flux code minimums.

[10] ABA is for Federally funded structures and very similar to ADA. Guides detailing the ABA-to-ADA differences are available. See Chapter 3 for accessibility in public rights-of-way (e.g., PROWAG).

3. Provide hole-less, hydraulic, passenger elevators when under 5 stories. When higher, and a traction elevator is used, have no regenerative (energy capturing) features.
4. Use only petroleum-based hydraulic oils.
5. Provide a code-compliant sump pit with a cover, flush with the elevator pit floor and that holds 400 lbs without deflection. Do not provide a sump pump.
6. Machine-room-less (MRL) elevators – Locate the control circuit disconnect, 120V lighting disconnect, and smoke and heat detector contacts inside the MRL.
7. Provide a non-proprietary controller and locate disconnect in direct view of it.
8. The Design Agency shall specify the elevator's operation during life safety emergency conditions based on code requirements rather than owner preferences, except in unique circumstances where LANL must make this determination.
9. Parking garages shall have a vestibule at the top landing if subject to weather and subsequently on all floors if possible (or SoW requires).

*Guidance: Special attention to detail while forming/pouring elevator pits is essential, especially for MRLs. Dimensions should be double-checked by LANL inspectors*

F. Roofing: Install cool roofs for new construction or when replacing roofs unless determined uneconomical by a life-cycle cost analysis. Only styrene-butadiene-styrene (SBS) or atatic-polypropylene (APP) modified bitumen systems are acceptable for low-slope applications. For mid-to high-slope applications (> 2:12), metal panel roofing may (and should) be employed. Other types of roofing systems may be used when approved in advance by the Chapter Point of Contact (POC).

G. Roof access: Hatches with extending ladders is the default expectation. Where not practical, extended stairways to a penthouse are preferred over fixed vertical ladders. Ships ladders or alternating tread stairs may be used in constrained areas with prior approval of chapter POC and AHJ. For buildings with multiple roof levels, access must be provided for equipment maintenance, with over-the-parapet ladders preferred.

H. Locksets: For interior doors, use Best Lock Corporation 9K Series cylindrical locksets with Style 14 or Style 15 levers. For exterior doors not equipped with exit devices, use Best 47H Series mortise locksets with Style 14 or Style 15 levers. LANL will supply and install Best 7-pin changeable cores.

I. Signage/Room Numbering.

1. Signs

a. Interior signs designating spaces shall include the space name and room number(s), shall be of appropriate size, and mounted at

appropriate locations in accordance with ABA requirements. Allowed materials per 10 1410, *Interior Signage*.

b. Floor loading: For each floor or portion thereof designed for *live loads* exceeding 50 psf, such design *live loads* shall be conspicuously posted in that part of each *story* in which they apply, using durable signs.

c. Assembly: Every room or space that is an assembly occupancy shall have the *occupant load* of the room or space posted in a conspicuous place, near the main *exit* or *exit access doorway* from the room or space, for the intended configurations.

d. Exterior wayfinding signs designating buildings are to be provided following the ESM, related Standard Details, and 10 1405, *Exterior Signage*.

e. Sign materials shall be durable and easy to maintain, providing reasonable ease of replacement and updating. A LANL standard specification for these signs is available upon request.

f. Refer to ESM Chapter 1, Section Z10 for information on standardized signs, labels, and tags for other-than-space identification.

2. Room Numbering

a. A four-digit room numbering scheme will be provided by LANL after a conceptual floor plan is developed, received, and LANL-approved. (Send conceptual drawings to fpr_team@lanl.gov to assign numbering scheme)

b. *Room Numbering should comply* with *ESM Ch. 4 Architectural, Section C – Interiors, Appendix A – Room Numbering*.

J. Minimum plumbing fixture counts shall satisfy the scope of work and the Project code of record. When modifying existing buildings, coordinate with the Architectural POC for existing occupant loads and requirements.

*Guidance: At time of writing, Chapter 1's "most stringent" rule dictated that the UPC counts, and not the NM Admin Code's reduction of same nor just the IBC, must be followed. Project circumstances may warrant exceeding even the UPC, and the users' input should be sought.*

K. Single-occupant restroom: For new facilities, additions that add restrooms, reconfiguration of existing restrooms (an IEBC Level 2B Alteration), or for IEBC Level 3 Alterations:

1. Wherever separate multi-occupant restroom facilities are provided, at least one (1) single-occupant restroom facility shall also be provided.

a. They shall be in the same general area as the multi-occupant facilities to the extent practical (wayfinding signage as appropriate).

b. Such restrooms shall also comply with ABA provisions and signage shall reflect the single-occupant and ABA characteristics.

c. Amenities provided in multi-occupant restrooms shall also be provided in single-occupant restrooms including but are not limited to bathroom accessories, showers/bathing, lockers, and mirrors.

d. Plumbing fixture total count shall be in accordance with applicable codes at a minimum and may exceed the code minimum in response to unique project requirements. The ratio of fixture count assignments shall be 45% male, 45% female, and 10% single-occupant equaling 100% of the total occupant load served.

e. Alternative ratios to above or other outcomes based on unique project circumstances require LANL Building Official approval.

L. Room Size and System Furniture: These guidelines ensure consistency across LANL in room design and system furniture planning. When designing these spaces, follow the LANL Furniture Standards (internal, will be provided) to ensure room sizes align with established furniture guidelines while maintaining occupancy loads in compliance with building occupancy requirements.

1. General Space Planning:

a. Room sizes shall be determined based on operation and functional needs, occupancy load, and code requirements.

b. Designs must consider efficient workflow, accessibility, and flexibility for future modifications.

c. Life safety is the top priority when determining minimum clearances and circulation paths around fixed equipment, furniture, and furniture systems within buildings. Egress routes must comply with IBC, NFPA 101, and accessibility requirements.

d. A/V infrastructure shall be integrated into the design to support user needs, ensuring appropriate power, data connections, blocking for equipment, and acoustics for effective communication and presentations.

2. Office and Workspaces:

a. Executive Office (Lab Director): A private office with a recommended size of 250 SF or larger. The final dimensions should be based on user needs, including furniture requirements and sufficient circulation space.

b. Executive Office (Senior Leadership): Recommended 10’ x 12’, or as required to accommodate user needs, system furniture, and proper circulation.

c. Typical Office: Recommended 10’ x 10’, or as required to accommodate user needs, system furniture, and proper circulation.

d. Private Workstations: Recommended 6’ x 6’ and 8’ x 8’ area per workstation, with allowance for partitions, storage, and ergonomic clearances.

e. Open Workstations: Recommended 6’ x 6’ area per workstation, with allowance for partitions, storage, and ergonomic clearances.

f. Shared Office: Recommended 8’ x 10’, per occupant, providing sufficient space for system furniture and collaboration.

3. System Furniture: If the Design Agency is responsible for incorporating furniture or furniture systems into the design, they must adhere to the LANL Furniture Standards for selecting system furniture, wall panel heights, and configurations.

4. Collaboration and Support Spaces:

a. Conference Rooms: Provide a suggested minimum of 15 net SF per occupant. The room size shall be determined based on occupant load factors. Conference rooms may also serve as multipurpose spaces, such as break rooms, collaboration or training rooms. To accommodate various functions, provide AV equipment to meet the needs of the users.

b. Break Rooms: Recommended size of 150 SF or as required by occupant load. The room shall provide adequate clearances for appliances, seating, and circulation.

M. Site Development and Landscaping

1. Follow ESM Chapter 4 reference *Site & Architectural Design Principles* document for landscaping requirements. When implementing site improvements and adding landscaping, ensure coordination with Civil Chapter 3 for additional requirements related to grading and drainage.

2. The design must maintain continuity and incorporate site planning, plant selection, irrigation efficiency, and long-term maintenance to promote aesthetics, habitat, and resilience of the campus. Landscaping shall contribute to stormwater management, erosion control, reduction of heat-island effect, and improve the physical landscape.

3. Seeding recommendations are updated regularly, and the design shall follow current guidelines and LANL-EPC environmental compliance requirements to ensure sustainability and regulatory adherence. Refer to LANL Master Specification Section 32 9219.

4. Site factors for planting, seeding, and sodding may exist separately or in various combinations. Design shall consider the following factors for landscaping and or re-vegetation of construction areas:

- Drainage
- Topography
- Soils
- Climatic data
- Existing Vegetation
- Security Requirements
- Pedestrian Circulation

5. When directed by SoW or LANL architect, include physical barriers for protection of landscape elements from autos or snow removal (e.g., concrete curbs, pipe barriers, fencing, etc.).

# Chapter 5 STRUCTURAL

## 1.0 COMMERCIAL DESIGN AND ANALYSIS REQUIREMENTS

This Chapter provides the minimum requirements for the structural design and construction of new and existing commercial (i.e., non-nuclear) structures, systems, and components (SSCs). These include nonbuilding structures[11], nonstructural components[12] and, as applicable, programmatic equipment[13].

Such design and construction shall be performed in accordance with the International Building Code (IBC), the International Existing Building Code (IEBC), and the structural standards referenced therein. Apply any section in the 2021 IBC not specifically referenced herein as it is written there. Modifications to the 2021 IBC and ASCE 7-16 provisions contained herein are intended to address LANL site-specific requirements. Where conflicts arise between the 2021 IBC or ASCE 7-16 and this TSM, this TSM prevails. Unless noted otherwise, section numbers included in this TSM chapter refer to the 2021 IBC.

Where this chapter modifies the 2021 IBC and/or ASCE 7-16 as indicated below, comply with the stated action:

- [Addition] – Add a new section, including a new section number, not shown in the 2021 IBC or ASCE 7-16.
- [Deletion] – Delete the referenced 2021 IBC or ASCE 7-16 section or a noted portion of a section.
- [Replacement] – Delete the referenced 2021 IBC or ASCE 7-16 section or a noted portion and replace it with the narrative shown.
- [Supplement] – Add the narrative shown as a supplement to the narrative in the referenced section of the 2021 IBC or ASCE 7-16.

## 2.0 IBC CHAPTER 16 STRUCTURAL DESIGN

A. Table 1604.5 Risk Category of Buildings and Other Structures. [Supplement]

Add the following text at the end of foot note b.

A facility Explosives Safety Site Plan, approved by the LANL DOE Field Office, constitutes an analysis of the quantity-distance relationships for the quantity of

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[11] Nonbuilding structures include structures in IBC Occupancy Classification Groups H, F, S, U and others included in ESM Chapter 16 IBC-GEN in-scope tables, and ASCE 7. For specific details regarding the type of SSCs under the scope of ASCE 7 seismic and wind design requirements, refer to ASCE 7 Sections 11.1.2 and 26.1.1. ASCE 7 Chapter 15, as referenced by IBC 1613.1, includes seismic design requirements for self-supporting nonbuilding structures. Examples include pipe racks, storage racks, earth retaining structures, chimneys, stacks, tanks, and vessels to name a few. It is important to note that certain nonbuilding structures are outside the scope of IBC and ASCE 7. These include vehicular bridges, electrical transmission towers, hydraulic structures, buried utility lines and their appurtenance and nuclear reactors.

[12] ASCE 7 Chapter 13, referenced by IBC Section 1613.1, includes seismic design requirements for nonstructural components that are permanently attached to structures. These components include architectural, mechanical, electrical, and piping systems (MEP).

[13] Anchorage and bracing requirements for programmatic equipment (e.g., specialized tools, machinery, and equipment that are not facility, utility, infrastructure or environmental program related) are specifically addressed in Section 9.0 of this TSM Chapter.
ASCE 7 Chapter 26, as referenced in IBC Section 1609.1.1, includes wind design requirements for building structures, nonbuilding structures, and nonstructural components within the scope of the IBC.

explosive materials permitted in the facility to ensure there is no threat to the public from blast pressures, fragments, or noise. Upon approval of same by NA-LA, these facilities may be taken as Risk Category II[14].

B. Section 1607 Live Loads

1. 1607.1.1 Live loads posting [Addition]

   The Structural Engineer of Record (SEOR) is required to clearly indicate in floor plan drawings the areas with live loads greater than 50 psf (e.g., using keyed notes).

2. 1607.11.5 Experimental explosion loads. [Addition]

   a. Reactions from experimental explosion containment structures, due to explosions within them, shall be considered live loads that act concurrently with floor and roof live loads and that have a load factor of 1.0 for both strength design and allowable stress design.

   b. External loads from experimental explosions shall comply with DOE-STD-1212 Section 7.2 and shall be considered live loads that act concurrently with floor and roof live loads and that have a load factor of 1.0 for both strength design and allowable stress design.

C. Section 1608 Snow Loads

1. 1608.2 Ground snow loads. [Replacement]

   The ground snow load to be used in determining the design snow load for roofs shall be 30 psf.

D. Section 1609 Wind Loads[15]

1. 1609.1.1 Determination of wind loads. [Replacement]

   Replace the second sentence of the first paragraph with the following:

   The basic design wind speed, V, and the exposure category shall be as indicated in Section 1609.[16]

2. 1609.3 Basic design wind speed. [Replacement]

   The basic design wind speed, V, for the determination of wind loads shall be as follows:

   - 99 mph for Risk Category I,
   - 104 mph for Risk Category II, and
   - 110 mph for Risk Category III, and
   - 115 mph for Risk Category IV.

[14] This exemption only considers effect of explosives on assignment of Risk Category. Risk Category may be greater than RC II for other reasons such as operability during or after seismic events, mission importance and security.

[15] Wind and Seismic Detailing guidance: Structures with wind demands/effects greater than seismic demands/effects (i.e., "governed" by wind load) shall meet the seismic detailing requirement and limitations of IBC and ASCE 7 as required per IBC Section 1604.9.

[16] For photovoltaic (PV) wind design, refer to SEAOC reports PV2-2012 and PV2-2017.

3. 1609.4 Exposure category. [Replacement]

   The exposure category shall be taken as Exposure C for each wind direction considered.

E. Section 1612 Flood Loads

1. 1612.3 Establishment of Flood hazard areas. [Replacement]

   Pajarito Canyon, Los Alamos Canyon, and Water Canyon shall be considered flood hazard areas, the design flood elevations shall be determined in accordance with Section 1612.3.1.

2. 1612.3.1 Design flood elevations. [Replacement]

   Replace the first paragraph in **Section 1612.3.1** with the following:

   To determine the design flood elevations, the engineer of record is required to do one of the following:

F. Section 1613 Earthquake Loads

1. 1613.2 Seismic ground motion values. [Replacement]

   The following parameters shall be used for all Risk Categories:

   a. **1613.2.1 Mapped acceleration parameters**. Mapped acceleration parameters shall not be used.

   b. **1613.2.2 Site class definitions**. The site class shall be taken as Site Class D except as demonstrated otherwise by site specific geotechnical information that other Site Class applies.[17]

   c. **1613.2.3 Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters**. The maximum considered earthquake spectral response acceleration for short periods, $S_{MS}$, and at 1-second period, $S_{M1}$, adjusted for site class effects shall be determined as follows:

| Parameter | TA-16 | TA-03 | TA-55/50 | Sitewide |
|---|---|---|---|---|
| At short periods, $S_{MS}$ | 1.02 | 0.99 | 0.90 | 1.02 |
| At long periods, $S_{M1}$ | 0.89 | 0.96 | 1.02 | 1.02 |

   d. **1613.2.4 Design spectral response acceleration parameters**. Five-percent damped design spectral response acceleration at short periods, $S_{DS}$, and at 1-second period, $S_{D1}$, shall be determined as follows:

[17] To meet Site Class C requirements, borings must be deeper than what has become the norm for LANL geotechnical investigations. Refer to ASCE 7 Ch. 20 for applicable requirements. If the geotechnical investigation indicates that Site Class E or F exist, IBC Section 1809.13 Footing seismic ties is applicable and shall be followed.

| Parameter | TA-16 | TA-03 | TA-55/50 | Sitewide |
|---|---|---|---|---|
| At short periods, $S_{DS}$ | 0.68 | 0.66 | 0.60 | 0.68 |
| At long periods, $S_{D1}$ | 0.59 | 0.64 | 0.68 | 0.68 |

e. **1613.2.5 Determination of seismic design category**. The seismic design category shall be taken as Seismic Design Category D.

2. 1613.4 Amendments to ASCE 7. [Addition]

a. **1613.4.1 Siting**. Modify ASCE 7 Section 11.8.1 to read as follows:

**11.8.1 Site Limitation**. Hazardous waste treatment, storage and disposal facilities must not be located within 200 feet of a fault that has had displacement within the last 11,000 years.

b. **1613.4.2 Design Approach to Commercially Fabricated Buildings Used in Multi-State Jurisdictions**. Refer to Section 6.0 of this chapter.

c. **1613.4.3 Nonstructural Components Exempt from Seismic Design**. Modify ASCE 7 Section 13.1.4, Numerals 1 and 2 to read as follows[18]:

1. Furniture except for cabinets as noted in ASCE 7 Table 13.5-1[19].

2. Temporary[20] or movable components/equipment[21].

d. **1613.4.5 Restraint of Non-Facility Equipment (e.g., Programmatic, Utilities, Infrastructure, Environmental Remediation)**. Follow Section 9.0 of this chapter.

G. **Section 1617 Accidental Blast Loads.** [Addition]

1. Permanent explosive facilities shall comply with DOE-STD-1212 Section 7.1. When evaluating for accidental blast load ($A_B$), $A_B$ shall replace E (earthquake load) in the load combination equations. All potential blast effects shall be considered including blast overpressure, gas pressure, fragments, and ground shock.

2. The design of all new facilities containing explosives, or those that can be affected by detonation (inadvertent or planned) of explosives, shall comply with DOE-STD-1212 Section 7.5.[22]

[18] The ASCE 7 exemptions are modified because LANL is both the Building Official and the owner. Refer to ASCE 7 C13.1.1 and C13.1.4 for details.
[19] Cabinet-like furniture also is not exempt (e.g., relatively tall, narrow, and heavy components/equipment, such as some safes and shelves).
[20] Temporary components are those that remain in place for 3 years or less (defined in the Conduct of Engineering Glossary).
[21] Movable components/equipment that are expected to remain in place for periods of 3 years or longer, should be considered permanent for the purposes of this section. Non-permanent anchorage such as detachable cable restraints, chains, brackets, and similar alternatives are acceptable restraint options for these items. Contact the ESM Ch. 5 POC for guidance.
[22] Per DOE-STD-1020 Section 2.2.5, it is permissible to use DOE-STD-1212 to satisfy the provisions of 10 CFR Part 851. This portion of "1020" also refers to 29 CFR Part 1910.109.

*Note: This requirement also applies to significant (e.g., IEBC Alteration Level 3) modifications of facilities containing explosives, or of facilities that can be affected by detonation (inadvertent or planned) of explosives.*

H. Section 1618 Minimum Antiterrorism Structural Design Measures. [Addition]

Structural design measures for progressive-collapse avoidance and window protection presented in DOD UFC 4-010-01 shall be considered for those buildings where there is a credible terrorist threat. LANL Physical Security (PS) Division shall specify (to the LANL Project Manager) whether these minimum antiterrorism measures are to be implemented; see also ESM Chapter 9, Facility Protection and Security.

I. **Section 1619 Dynamic Loads and Supports for Vibrating Machinery.** [Addition]

1. Machinery foundations shall be designed in accordance with ACI 351.2R-10 *Report on Foundations for Static Equipment*; ACI 351.3R-18 *Report on Foundations for Dynamic Equipment*, equipment manufacturer's recommendations, and published design procedures and criteria for dynamic analysis.
2. If equipment manufacturer's vibration criteria are not available, the maximum velocity of movement during steady-state normal operation shall be limited to 0.12 inch (3.0 mm) per second for centrifugal machines and to 0.15 inch (3.8 mm) per second for reciprocating machines.
3. For centrifugal machinery greater than 500 horsepower, support structures or foundations shall be designed for the expected dynamic forces using dynamic analysis procedures.
4. For grade-mounted centrifugal machinery 500 horsepower or less, unless specified otherwise by the equipment manufacturer, and in the absence of a detailed dynamic analysis, the foundation weight shall be designed to be at least three times the total machinery weight. Weight of a grouted equipment skid can be considered part of the foundation weight for this provision.
5. For reciprocating machinery greater than 200 horsepower, support structures or foundations shall be designed for the expected dynamic forces using dynamic analysis procedures.
6. Unless specified otherwise by the manufacturer, for grade-mounted reciprocating machinery 200 horsepower or less, in the absence of a detailed dynamic analysis, the foundation weight shall be designed to be at least five times the total machinery weight. Weight of a grouted equipment skid can be considered part of the foundation weight for this provision.

7. The allowable soil-bearing or allowable pile capacity for foundations for equipment designed for dynamic loads shall be a maximum of half of the normal allowable for static loads.

8. The maximum eccentricity between the center of gravity of the combined weight of the foundation and machinery and the bearing surface shall be 5% in each direction.

9. Unless otherwise specified in the subcontract documents, if equipment manufacturer's frequency criteria are not available, structures and foundations that support vibrating equipment shall have primary modes of natural frequency that are outside the range of 0.80 to 1.20 times the exciting frequency.

## 3.0 IBC CHAPTER 17 SPECIAL INSPECTIONS AND TESTS

Refer to LANL ESM Chapter 16 Building Code Program for related amendments to this and other IBC chapters with structural content.

## 4.0 IBC CHAPTER 18 SOILS AND FOUNDATIONS

A. 1803.5 Investigated Conditions. [Supplement]

Add the following text at the end of Section 1803.5.12, Numeral 1:

An acceptable approach for obtaining such seismic earth pressures on foundation walls (i.e., exterior embedded building walls or basement walls) is to use of the Simplified Method presented in ASCE 4-16 Section 8.2.2. Similarly, for earth retaining walls such pressures can be obtained using the Mononobe-Okabe approach in accordance with ASCE 4-16 Sections 8.3 and C8.3, provided that the wall displacements required to develop the active earth pressure can be justified without loss of wall function.

B. Section 1808 Foundations

1. **1808.1 General.** [Supplement]:

Permanent buildings and similar structures shall have a permanent foundation (e.g., full perimeter support, rodent-excluding, no trailer skirting, etc.). Permanent is anything not Temporary (which is defined in the Conduct of Engineering Glossary).

**Exception:** For non-temporary relocatable buildings (as defined in ESM Chapter 16, Section IBC-GEN)[23], a permanent foundation may be achieved by placing gravity bearing pads on 24 inches of non-frost susceptible ground or fill (95% compacted granular material with less than 6% material passing the 200 sieve)*, and providing insulated skirting around the perimeter of the buildings, and by providing a means to resist the lateral and uplift forces that result from seismic and wind loads. *For temporary foundations for temporary relocatable buildings, see LANL Standard Detail ST-Z1052-1 and -2.*

[23] A transportable is an easily moved prefabricated building (e.g., a trailer or manufactured office) generally intended for less than a 20-year life. See ESM Ch 1 Sect. Z10 on design goals and ESM Ch 16 IBC-GEN on temporary facilities, relocatable buildings, and prefabs.

*If fill is used, it must replace the existing material to a depth of at least 24 inches.

C. Section 1809 Shallow Foundations

1. 1809.5 Frost protection. [Replacement]

Replace numeral 1 with the following:

Extending below the ground surface to a depth of 36”.

## 5.0 IBC CHAPTER 19 CONCRETE

A. Section 1901 General

1. **1901.3 Anchoring to concrete**:

1901.3.1 Post-installed anchors. [Addition]

Post-installed anchor design shall provide for limited anchor relocation (at least ± 1 inch) to facilitate anchor installation. Due consideration shall be given to the location tolerances of the anchors to avoid interferences with reinforcement in concrete.

Post-installed anchors shall be qualified for use in cracked concrete under earthquake loads in accordance with ACI 355.2 or ACI 355.4. Additionally, the intended use of the product in the field must align with the USES and CONDITIONS OF USE requirements provided in the corresponding qualification or evaluation report (e.g., ICC ESR or IAPMO ER).

**Exception:** Seismic-related provisions are not applicable to anchoring that is seismically-exempt per Section 2.0.F.2.c of this chapter.

B. Section 1904 Durability Requirements

1. **1904.3 Mass Concrete** [Addition]:

a. Mass concrete is defined as “any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration.” *In general, a placement of structural concrete with a minimum dimension $\geq$ 4 ft should be considered mass concrete. Similar considerations should be given to other concrete placement that do not meet this minimum dimension but contain Type III cement, accelerating admixtures, or cementitious materials in excess of 660 lb/yd$^3$ of concrete. Consideration should also be given to placements that trap heat.*

b. The Construction Documents shall designate those portions of the structure, or concrete placement that are to be treated as mass concrete. The Project Specification Section (e.g., 03 3001, *Reinforced Concrete*) shall adopt the ACI 301, Section 8 requirements. The Structural Engineer of Record (SEOR) shall review the project-specific version of Section 03 3001 against the checklists presented in ACI 301 (i.e., Mandatory, Optional

Requirements, and Submittals) to ensure that this Section adequately addresses mass concrete.

i. In lieu of mass concrete designation and specification requirements, the SEOR can opt to demonstrate (analytically, using ACI 207.2R) that these requirements are not required/applicable.

2. 1904.4 Concrete Mix Design [Addition]

a. LANL Master Specification Section 03 3001 is an acceptable approach to satisfy ACI reinforced concrete requirements and recognizes LANL pre-approved mixes available from the local supplier within a practicable travel distance. Use of this template is highly recommended.

## 6.0 IBC CHAPTER 21 MASONRY

A. 2101.2.1 - Allowable Stress Design [Addition]

Masonry must be designed as reinforced unless the element is isolated from the structure so that vertical and lateral forces are not imparted to the element.

B. 2101.2.2 - Strength Design [Addition]

Masonry must be designed as reinforced unless the element is isolated from the structure so that vertical and lateral forces are not imparted to the element.

C. 2101.2.3 - Empirical Design [Addition]

Do not design masonry according to the empirical method.

D. 2101.4 - Shear Wall Construction [Addition]

Shear walls must be of running bond construction only; stack bond construction is not permitted.

E. 2106.2 – Anchoring to Masonry [Addition]

Anchors in masonry must be designed in accordance with TMS 402-16. Additionally, at least one of the following must be satisfied:

1. Anchors in tension are designed to be governed by the tensile strength of a ductile steel element.
2. Anchors are designed for the maximum load that can be transmitted to the anchors from a ductile attachment, considering both material overstrength and strain hardening of the attachment.
3. Anchors are designed for the maximum load that can be transmitted to the anchors by a non-yielding attachment.
4. Anchors are designed for the maximum load obtained from design load combinations that include E, where the effect of horizontal ground motion, $Q_E$, is multiplied by $\Omega_o$.

## 7.0 IBC CHAPTER 22 STEEL

A. **2205.1 – General** [Supplement]

Add the following to the end of the paragraph:

Design structural steel floor framing systems for vibration serviceability in accordance with AISC Design Guide 11.

## 8.0 COMMERCIALLY FABRICATED BUILDINGS USED IN MULTI-STATE JURISDICTIONS (DESIGN APPROACH)[24]

A. Approval

From a structural standpoint, approval is currently limited to the following vendors (others with ESM Chapter 5 POC written permission): ARMAG, MSSI, and US Chemical.

B. Applicability

Risk Category I, II, and III (per ASCE 7 Table 1.5-1), commercially fabricated building-like structures designated as ML-4 that are not included as credited SSCs in nuclear or radiological safety documentation.

C. Design

1. Commercially fabricated building-like structures that are not one of the structural systems described in ASCE 7 Chapter 12 should be designed and detailed in accordance with ASCE 7 Section 15.5 for non-building structures similar to buildings, as stipulated in ASCE 7 Section 11.1.3.
2. If a nationally marketed structure type does not fit into the categories included in ASCE Section 12.2 or 15.5, then ASCE 7 Section 15.6 covering non-building structures not similar to buildings shall be used, and the default structure type per Table 15.4-2 shall be *"All other self-supporting structures, tanks, or vessels not covered above or by reference standards that are not similar to buildings."*

## 9.0 RESTRAINT OF NON-FACILITY EQUIPMENT

Restraint (i.e., anchorage and/or bracing) of non-facility (e.g., programmatic) equipment is required in either of the following two conditions:

A. When required by the manufacturer for normal operation.

1. If this is the sole reason restraint is required (i.e., seismic restraint per paragraph B below is not required), then the design does not need to

[24] A commercial building that is marketed nationally is termed "commercial building structure." Typically, these are factory built, transported to the site on trailers, and anchored to engineered foundations. At LANL, the intended purpose for these is to serve as storage facilities, control facilities for experimental work, weather proofing structures for materials, equipment or piping systems, security portals for entry access, etc. They are sometimes occupied, but not continuously; the occupancy is limited for the special purpose of the facility. These structures have building geometries and framing systems that may be different from the broader class of occupied structures addressed in ASCE 7, Chapter 12. See ESM Ch 16 IBC-GEN Section 10.0 "Prefab Structure Requirements".

follow TSM Ch. 5 if the manufacturer provides alternative design requirements.

B. In all other cases, seismic restraint is required unless the equipment is "Seismically Exempt" per Section 2.0.F.2.c of this chapter.

1. If seismic restraint is required, the design must comply with ASCE 7-16 Chapter 13 requirements.

2. An alternative method[25] may be proposed to the Structural POC for approval on behalf of the LANL Building Official, provided[26]:

a. An analysis that indicates the interaction effects of the unrestrained equipment[27] are acceptable at the Design Basis Earthquake (DBE).

b. The equipment will be in an essentially unoccupied area[28] and is protected as such through administrative or engineering control.

c. Anchorage and/or restraint is not practical.

3. In an existing facility, unless the building is undergoing an alteration that involves the structural provisions of IEBC (2021) in Section 304; Chapter 5; or Sections 706, 805, or 906; it may be that the restraint can be designed to lesser requirements; see Existing SSC paragraph in TSM Ch. 16 (leading to ESM Ch. 16, IBC-GEN App B, Code of Record/Structural material).

*Notes: Both of the above conditions (i.e., 9.0.A and 9.0.B), also apply to equipment installed outside of a building.*

*Seismic restraint of laboratory equipment inside of a building can be achieved using the restraint recommendations in FEMA E-74 Section 6.5.29.*

## 10.0 STRUCTURAL LANL MASTER SPECIFICATIONS

A. Structural discipline LANL Master Specification templates contain materials, methods, and quality related content specific to LANL. Projects shall meet their requirements.

## 11.0 RECOMMENDED STRUCTURAL REFERENCES

The TSM webpage provides a list of structural references that offer guidelines, best practices, design examples, and recommendations to support compliance with the 2021 IBC and its referenced standards.

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[25] Acceptable and conservatively bias methods to evaluate sliding, rocking and uplift of rigid unanchored equipment is provided in ASCE 4-16, Chapter 11 and Attachment 11A.

[26] In all cases, per ASCE 7 C13.1.1, equipment must be anchored if it is permanently attached to utility services (e.g., electricity, gas, water).

[27] Seismic interaction is the physical interaction of any non-facility equipment with the structure or nearby items caused by relative motions from an earthquake. The interaction analysis should consider interaction effects due to rocking, swaying, overturning, sliding, impact, etc.

[28] I.e., incidental occupancy: occupied for a total of less than 2 hours/day, yearly average (RP 8 exemption 1.3.d utilized herein). Not the same as *incidental use* (IBC sec. 509 term relating to certain adjunct uses).

[29] Safe-T-Proof Laboratory Equipment Anchorage Kit (STP-MP-203-09) in accordance with ICC ES ESR-4167, Gripple seismic bracing kits, B-line seismic bracing kits, Unistrut seismic bracing, or other approved systems may be used to achieve seismic restraint.

# Chapter 6 MECHANICAL

## 1.0 GENERAL—DESIGN DOCUMENTATION

A. General

1. Provide documentation to include, but not limited to, the following:

   a. Calculations: Note the source of each formula or method used, list all assumptions and exceptions, and define all units. Provide copies of tabulated data used. If a computer program is used (e.g., for HVAC sizing), provide input data in the calculation.

2. HVAC System Calculations: Heating and cooling loads, ventilation, exhaust and outside air requirements, building pressurization, humidity control when required, duct sizing, and air system pressure drops for equipment selection. Correct calculations for elevation.

3. Piping System Calculations: Flow rates, pipe sizing with friction factors, velocities, expansion/contraction, and system equipment pressure drops for pump selection.

4. Equipment Selection Criteria: Include flow rates, pressure or head requirements, operating temperatures, efficiency, energy consumption, and sound ratings. If manufacturer selection program is used, verify that elevation correction for motor size is properly performed.

5. Vibration Isolation/Sound Attenuation Measures: List uncorrected and corrected equipment criteria in the design documentation.

6. Plumbing System Calculations: Provide for water supply and drainage fixture unit requirements, roof drainage, and makeup water requirements for mechanical systems.

7. Plumbing and Piping Systems: Riser/schematic diagrams, isometrics, and calculations are required for the following systems: water, waste/vent, natural gas, roof/overflow drains, steam & condensate, and refrigeration. Plans and calculations are required for irrigation systems, gases, and other liquid and vapor systems.

8. Include copies of catalog sheets showing equipment performance points for all major equipment included in the systems design.

9. Mechanical rooms: provide layout complete with estimated equipment sizes, pipe routing, and sizing to LANL for approval prior to design completion.

10. Mechanical system design, materials, and construction shall meet ASHRAE 55, 62.1, and 90.1.

B. HVAC Options – Life Cycle Cost Analysis (LCCA)

1. Unless another building design life is specified in the statement of work, select mechanical systems using a 40-year LCCA. Use first cost, utility costs, operating efficiency, maintenance, and unit replacement costs to determine the most life cycle cost efficient mechanical system.

## 2.0 GENERAL—EQUIPMENT/PIPING IDENTIFICATION

A. General

1. For fume hoods and other local exhaust ventilation systems, label exhaust fans with a permanent printed label indicating fan design static pressure, RPM, and motor current. The data for these labels is to be supplied by the test, adjust, and balance (TAB) agency.

## 3.0 GENERAL—SOUND CONTROL

A. General

1. Specify that equipment (fans, chillers, VAV terminal units, air handling units, etc.) comply with the sound rating of the applicable standards of the Air Conditioning, Heating and Refrigeration Institute (AHRI) or the Air Movement and Control Association (AMCA).
2. For mechanical equipment, provide sound power (preferred) or sound pressure levels for all eight octave band center frequencies from 63 to 8000 Hz.
3. For sound control materials, specify sound transmission loss (TL) capabilities and/or sound absorption coefficients, depending on the material. State TL in decibels (dB) and octave band center frequencies for both.
4. Seal penetrations through walls, floors, and ceilings.

B. Acoustical Design

1. The following criteria are acceptable for mechanical system noise levels in normally occupied spaces, as measured during unoccupied times (NC=Noise Criteria; RC=Room Criterion).

Table D10-30GEN-1

| | |
|---|---|
| 1. Conference Rooms | NC/RC 25-35 |
| 2. Private Offices | NC/RC 25-35 |
| 3. Open Plan Offices | NC/RC 30-40 |
| 4. Public Areas & Corridors | NC/RC 35-45 |
| 5. Computer/Business Machines | NC/RC 40-45 |
| 6. Laboratories (with fume hoods) | NC/RC 40-50 |

C. Fan Noise

1. Locate duct silencers as close to equipment as is possible and practical, while not violating the silencer manufacturer’s installation instructions.
2. Select silencers for the lowest possible static pressure drop, while still providing the specified insertion loss; specify to have a certified dynamic insertion loss (DIL) in decibels for the critical frequency or frequencies of concern, not less than the calculated requirement.
3. Where conditions prohibit the use of acoustic fill used in conventional silencers, use packless duct silencers.

## 4.0 GENERAL—VIBRATION CONTROL

A. General

1. For criteria on vibration and vibration control, refer to the ASHRAE Application and Fundamentals Handbooks and NEBB publication "Sound and Vibration Design and Analysis."
2. The equipment vibration severity rating for vibration on equipment structure or bearing caps shall be "slightly rough" or better per ASHRAE Applications Handbook (*Chapter 49 Figure 42 in 2023)*.

## 5.0 PIPING—CROSS CONNECTION CONTROL

A. Backflow Preventers (BFPs)

1. Locate building and fire protection BFPs inside the building, when possible, to prevent freezing and facilitate maintenance.
   a. For inside installations, provide a floor drain, connected to the sanitary sewer, near the BFP, sized to handle a full-open condition; do not install BFPs in areas without reliable drainage. Discharge BFPs at riser through drain/collection pipe to building exterior.
   b. Locate outside BFPs above ground in heated enclosures (e.g., "Hot Boxes") set on concrete pads and protect units from freezing; ESM Civil POC must approve outside installations in heated enclosures.
2. Provide parallel BFPs if building water supply cannot be interrupted in critical systems.

B. Temporary Buildings[30]

1. Provide a pressure-reducing valve (PRV) with a check valve in the potable water service line to each temporary building (trailer, transportable, Armag, etc.) as required to limit to 80 psig.
2. Refer to Mechanical, ST-D2020-2, Sheet 2, for PRV detail.

## 6.0 EMERGENCY SHOWERS AND EYE WASH STATIONS

A. For tempered water for emergency showers and eyewashes, provide a prepackaged, fully engineered and tested, mixing valve assembly furnished by the manufacturer of the emergency equipment, per ANSI Z358.1-2014. Provide a discharge temperature of 80–100°F.

B. Drains are not required to be provided for eye washes, safety showers, or combination installations, and not routed to sanitary drains or storm drains. If installed, the drains shall be routed to a holding tank capable of accepting a minimum full rated flow (not less than 20 GPM for 15 min.) for a single installation; sampling of collected water will determine appropriate disposal path.

[30] Defined in Conduct of Engineering Glossary

## 7.0 PLUMBING—GENERAL

A. Provide a recirculation pump in the hot water system when the developed length of piping from the heater to the fixture exceeds 100 feet. Set the aquastat at 95°F to control the pump. Use a timeclock to save energy during off-hours.

*Guidance: In installations where the hot water use is fairly continuous 24/7, do not use a pump.*

B. Minimize the number of floor drains in equipment rooms to prevent possible contamination (oil, etc.) transfer to the sanitary sewer system.

C. Route drain piping from equipment close to walls or equipment to minimize tripping hazards.

D. Isolation valves shall be installed to facilitate maintenance.

E. Refer to Chapter 4 for fixture count direction.

## 8.0 PIPING—STORM WATER

A. General

1. Design roof drain system for 2.25 inches of rainfall in a 1-hour period.

   a. To prevent ice build-up, do not discharge storm water on the north side of the building near doors, sidewalks, etc. Route storm water away from the building and pedestrian walkways.

2. Provide concrete splash blocks, river rocks, or similar, under down spouts to prevent ground erosion.

## 9.0 PIPING—COMPRESSED AIR INCLUDING BREATHING AIR

A. General

1. Determine free air delivery (FAD) cfm (actual volume flow rate of compressed air converted back to the inlet ambient conditions of the compressor), including required elevation correction and consideration that there is a good possibility of sizable diversity in demand.

2. Design piping to eliminate areas where water may accumulate; e.g., slope piping to oil/water separators, specify drain valves or traps at low points, etc.

3. Provide a commercial oil/water separator in drain piping from a lubricated compressor system that discharges into the sanitary sewer. Oil-less/oil-free compressor piping systems do not require an oil/water separator but do require an automatic no-loss drain valve. Refer to the compressed air piping drawings referenced below for details.

B. Elevation (Altitude) Correction

1. Derate the compressor free air delivered from what is listed in the manufacturer's catalog data to account for elevation and temperature[31].

C. System Components

1. Aftercooler: Equip each compressor with an aftercooler sized to provide a 5–20°F approach temperature.
2. Air Dryers: Use a refrigerated air dryer (35–38°F pressure dew point) when the compressed air system's ambient temperature is always 40°F and above. For portions of the system below 40°F ambient temperature, use a regenerative air dryer (-40°F pressure dew point).[32]

*Note: Heatless regenerative air dryers typically consume 5–18 percent of compressed air capacity.*

3. Intake Air Piping: Take intake air from the cleanest possible location. Avoid air intakes from dirty locations within the building, and hot (greater than 100°F) or humid locations.
4. Air Intake Filter: Equip the compressor inlet with a filter to remove dirt from the air.
5. Receiver: Equip each compressed air system with a receiver tank to dampen pulsations; equip with a pressure gauge, safety relief valve, and drain valve, and an NBIC Numbered and Registered tank.
6. Mechanical Air/Water Separator: Provide separators with the compressor package to remove water that has condensed in the aftercooler of the compressor.
7. Sound Attenuation: For applications requiring low noise (below 85 dBa), specify a sound enclosure for a rotary screw compressor or intake filter/silencers and/or mufflers for reciprocating compressors.

D. Outdoor Installations

1. Specify a compressor that is factory-rated for outdoor use down to 5°F.
2. To protect the unit from weather and freezing, equip the compressor with the following:
   a. TEFC motors and NEMA 4 controls, starters, and pressure switches.
   b. Heaters as recommended by manufacturer.
   c. Watertight intake filters.
   d. Heat-trace air/water separators, receivers, and condensate drain piping.

[31] Rule of thumb is a 30% deration, but this could vary by a few percentage points based on the design pressure of the compressed air system.
[32] Prevents condensate freeze-up

## 10.0 HVAC—ELEVATION/CLIMATIC CRITERIA AND HEAT GAIN EQUATIONS

A. See Chapter 1 for elevation, latitude/longitude, barometric pressure, air density, and air density ratio values.

B. Heating Degree-Days (annual mean): 6219 at 65°F base; 2680 at 50°F base.

C. Cooling Degree-Days (annual mean): 2187 at 50°F base, 272 at 65°F base.

D. Correct Q for elevation. Values for 7500 feet (*suitable for many locations/situations*) are:

*Q (sensible heat)(Btu/hr) = 1.08 X 0.76 (@W = 0) X cfm X ⊿t*

*Q (latent heat)(Btu/hr) = 0.68 X 0.760.52 X cfm X ⊿W (gr.) (at sea level 0.52 would be 0.68)*

*Q (total heat)(Btu/hr) = 4.50 X 0.76 X cfm X ⊿h*

*Where:*

*cfm = Air flow Rate, cubic feet/min.*

*⊿W (gr) = Humidity Ratio Difference, gr. water/lb. dry air.*

*⊿h = Enthalpy Difference, Btu/lb. dry air.*

*W = Humidity Ratio, lb. water/lb. dry air.*

*⊿t = Temperature Difference, degrees F.*

E. For HVAC system sizing/design, use data in the 2021 ASHRAE Fundamentals Handbook (WMO#723654), which is based on weather data from the Los Alamos Airport.

1. If Los Alamos, NM weather data is included as part of a commercially available HVAC calculation software program, this information may be used in lieu of above.

## 11.0 HVAC—ELEVATION CORRECTION

*Guidance: At LANL's elevation, the air pressure and density are lower than at sea level, the condition for which HVAC equipment is designed/rated. Therefore, HVAC equipment operating at LANL produces less than its catalog rating. Correcting for this during design is required so that procurement of appropriately larger equipment occurs.*

A. It is the responsibility of the Engineer to select equipment to meet the requirements at LANL's 7,500-foot elevation; correct (adjust) catalog data before applying it in the design. *Guidance is available in ESM Ch. 6 D30HVAC*.

1. Derate air-cooled equipment (e.g., chillers, coils, condensers, cooling towers, VAVs, VFDs) for elevation.

2. Derate boilers, furnaces, and gas-fired heat exchangers in a similar manner.

B. Indicate only the calculated, actual operating parameters (capacity, static pressure, cooling/heating loads) required at 7500 ft elevation on the design drawings and in the technical specifications. Only a statement such as "ALL

CAPACITIES SHOWN OR INDICATED ARE AT 7500 FT ELEVATION*" should be included in/on same*.

C. Obtain equipment selection data from the equipment manufacturer to back up equipment selections.

## 12.0 CHEMICAL WATER TREATMENT

A. Provide chemical treatment for water in HVAC systems (e.g., steam, hot water, heating, cooling systems) to address LANL's higher-than-neutral pH and silica scaling problems.

## 13.0 HVAC—COILS – HEATING/COOLING

A. General

1. Provide Air Conditioning, Heating, and Refrigeration Institute (AHRI)-certified heating and cooling coils for central station HVAC units and field built-up systems.
2. For coil selection, use a manufacturer's computerized selection program to facilitate selection for the most energy efficient system, and to obtain the coil rated performance data in accordance with AHRI Standard 410, *Forced-Circulation Air-Cooling and Air-Heating Coils*, Table 1, Range of Standard Rating Conditions: https://ahrinet.org .
3. Limit air velocities of wet coils (these both cool and dehumidify) to values that prevent water carryover into the ductwork.

## 14.0 HVAC—PREHEAT COILS

A. General

1. Building air handling units shall include a preheat coil upstream of chilled water or hot water reheat coils. The preheat coil shall be sized to heat building from initial 40°F degrees to 55°F degrees within one hour while maintaining minimum outside airflow requirements (for buildings with Building Automation Systems, the additional capacity to provide for minimum outside air requirements is not necessary if outside air dampers will be closed during warm-up).
2. Operate face and bypass coils with constant steam or water flow. Do not modulate flow.
3. Provide a sensor in the discharge air stream to maintain a constant discharge air temperature, regardless of variations in inlet air temperature.

B. Design

1. Design coils that serve 100 percent outside air systems for an entering air temperature of -10°F. For steam coils, oversize condensate-return piping to handle large condensate flow at startup.

2. Provide supply air preheat coils, using hot water or low-pressure steam, with the necessary controls, etc., to protect them from freezing. The following are acceptable systems:
    a. Hot water coil with circulating pump to maintain a minimum coil water velocity of 4 fps.
    b. Vertical tube integral face and bypass steam or water coils with clamshell type dampers to control airflow.[33]
    c. Steam coil with properly designed control valve, steam trap with check valve, and vacuum breaker.

## 15.0 HVAC—DESIGN TEMPERATURES

A. Outdoor
    1. Winter: 5°F dry bulb
    2. Summer: 89°F dry bulb, 60°F wet bulb

B. Indoor (Dry-Bulb)
    1. Cooling:
        a. General Comfort: 75°F.
        b. Mechanical/Electrical Rooms: Follow ESM Mechanical Section D30, *Ventilation*.
    2. Heating:
        a. Office/Laboratories: 72°F (general comfort)
        b. Mechanical Rooms: 50°F
        c. Storage Space (unoccupied): 55°F
        d. Warehouses: 50°F
        e. Kitchens: 60 degrees F
        f. Change Rooms: 75 degrees F

*Note: Program requirements may require different indoor design temperatures.*

## 16.0 HVAC—HUMIDITY CONTROL

A. Provide humidity control only when programmatic requirements specify humidity levels in a zone or zones (e.g., in computer/information technology areas to prevent the buildup of static electricity).
    1. Provide humidity monitoring system to automatically adjust building conditions as appropriate.[20]

[33] Integral face and bypass coils are used as a freeze protection measure. The temperature of the discharge air is controlled by proportioning entering air through the multiple heating and bypass channels of the face and bypass coils. The air is proportioned by clamshell-shaped dampers, which maintain a constant pressure drop, thus allowing a constant volume of air to pass through the unit.

2. Guidance: Humidity control is typically not practical for general comfort because of the dry Los Alamos climate.

B. When humidity is added to a space, provide an analysis (to prevent condensation) on where dew point temperatures will occur for exterior walls, roofs, and windows.

C. Provide humidification units with deionized water; Mechanical POC and FOD approval required for other sources.[34] Consult with humidifier representative for water quality requirements (conductivity in micro-ohms).

D. When using a mechanical cooling system for dehumidification, install the heating coil downstream of the cooling coil to provide reheat.

## 17.0 HVAC—PUMPS

A. Provide redundant pumps for all chilled water and heating hot water systems. Operate pumps in a lead/standby configuration.

B. Secondary pump containment (metal pan, angle iron barrier, etc.) may be required for systems handling caustic, contaminated, etc., fluids. Consult with the area Environmental or Industrial Hygiene and Safety (IHS) representative or customer for requirements.

C. Provide a steam-powered pump when condensate must be moved to a higher elevation or great distances.

1. If an electrical-powered condensate pump must be specified, provide an isolation valve between the pump and receiver to prevent draining the receiver during pump maintenance.

## 18.0 HVAC—SYSTEM DESIGN

A. Unoccupied Operation: Primary HVAC systems for office areas shall be designed to allow unoccupied shutdown and temperature setback and shall not provide primary cooling for rooms that require 24-hour consistent temperature control. Server rooms, telecommunications rooms, and other rooms that require 24-hour consistent temperature control shall be served by dedicated air conditioning systems as their primary cooling source. See also ESM Chapter 19 Communications Section D6010 Data Communications for additional HVAC requirements on such rooms.

B. Hazard Confinement Standards for HVAC Systems: Follow Table D30GEN-3 in Chapter 6 of the LANL ESM.

## 19.0 HVAC—HEATING SYSTEMS

A. General

[34] Tap water at LANL is high in silica and scale deposits will cause operational and maintenance issues. DI systems contain scale in vessels relatively easy to change/maintain.

1. For heating design loads, do not take credit for internal heat gains from equipment that is often de-energized, especially during off hours, e.g., lights, personal computers.
2. Design low-temperature heating hot-water systems for a maximum of 140° degrees F supply temperature.
3. For 100% outside air systems, use hydronic heating. Steam, electric-resistance, and other methods are allowed only with ESM Mechanical POC permission.
4. Electric-resistance heating systems shall not be used for space heating, except where proven to be life cycle cost effective.

   Exceptions:

   a. Where the total capacity of all electric-resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating systems serving the entire building.

   b. Where the total capacity of all electric-resistance heating systems serving the building is no more than 5 kW.

   c. Where an electric-resistance heating system serves an entire building that:

      - Has a conditioned floor area no greater than 5,000 square feet; and
      - Has no mechanical cooling, and
      - Is in an area where natural gas is not available, and an extension of a natural gas system is impractical**.**

   d. Where an electric-resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirements is supplied by site solar or recovered energy.

      - Where the electric-resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the calculated design heating load.
      - If electric-resistance heat is used in packaged equipment, first stage of heating shall be a heat pump.
5. When using TA-3 Powerhouse steam, design for incoming temperature of 400 deg F and 85 psig with ability to handle 80 operating pressure for equipment capacities. Civil POC may grant variance to this.
6. Locate the equipment room at the point of entry of the high-pressure steam distribution supply to the building. Provide a steam pressure relief valve (PRV) within the equipment room per LANL Mechanical Standard Drawing(s) ST-D3020-2, Steam PRV Station.

7. Mechanical rooms shall have redundant heating to prevent freeze-up in case of a boiler malfunction (e.g., gas heat, electric heat, or multiple boilers).
    a. When gas is available, it is preferred to use gas-fired radiant heaters with millivolt gas controls. Millivolt gas controls allow the unit to operate when there is an electrical power outage.
8. Entry vestibules: Provide a source of heat to prevent freezing of water on floor and reduce cold drafts in lobbies during peak use times.
9. Locate shell and tube heat exchanges so that the location of joints (unions, flanges, etc.) and adjacent piping, etc. are clear of the tube pulling space.
10. Stairwells: Provide a thermostatically controlled source of heat to prevent freezing of water on floor or in fire suppression system standpipes.

## 20.0 HVAC—BOILERS

A. A factory-authorized representative of the boiler manufacturer shall provide startup service, stack analysis, and training to the LANL operator. Test reports shall be furnished to LANL.

B. Provide boiler water treatment.

C. Provide a low NOx burner system, with a maximum NOx emission of 30 ppm, on all gas-fired boilers.

D. Provide boilers with minimum refractory.

E. Stacks: Design per the boiler manufacturer's requirements; e.g., do not exceed maximum stack weight on boiler, required draft at flue outlet, etc.

1. Route all gas vents to atmosphere above roof to minimize roof penetrations. Provide a separate vent line for each fuel train component. Side exterior wall penetrations are preferred.
2. Provide vent caps on boiler stacks to keep rain, birds, and debris out of the stack. To prevent downdrafts and to induce draft (regardless of wind conditions) on atmospheric-type boiler stacks, provide aerodynamic-type vent caps (e.g., www.fieldcontrols.com, and navigate to venting/vent caps).

F. Where required, provide two or more boilers with the determination of the proportion of load each will handle based on energy, redundancy, and maintenance requirements. *Guidance examples:*

1. Two boilers: 40 percent and 60 percent or 50 percent and 50 percent of system load.
2. Three boilers: 40 percent and 60 percent with standby at 60 percent of system load or 50, 50, 50-percent configuration.

3. When designing systems for multiple boilers, configure the piping to allow a primary/secondary pumping configuration, using redundant pumps on the secondary loop. Provide a dedicated primary pump for each boiler.

G. On boilers with power burners, provide a temperature indicator on the boiler exit breaching.

## 21.0 HVAC—COOLING

A. General

1. Design cooling systems using mechanical vapor compression equipment (direct expansion coils or chillers) when close (better than +/- 5°F) temperature control in the space is required.

## 22.0 HVAC—COOLING TOWERS

A. When used, follow ESM Chapter 6.

## 23.0 HVAC—BUILDING THERMOSTATIC ZONES

A. Permanent Partitions (floor-to-ceiling): Provide the following minimum thermostatic zones:

1. Each corner office on exterior walls
2. Each laboratory
3. Each conference room
4. Maximum of three (3) offices with similar exposure and/or internal loads
5. Each toilet room with a shower

B. Open Office Area (moveable partitions): Provide a thermostatic zone, 10-15 feet from the exterior wall, for each exposure (e.g., N, S, E, and W), and a thermostatic zone for the interior area, unless Mechanical POC gives variance. Each VAV box within the zone shall serve no more than 6 supply air diffusers.

## 24.0 HVAC—DIFFUSERS, GRILLES, REGISTERS, AND LOUVERS

A. Select diffusers, registers, grilles, and louvers based on ASHRAE, SMACNA, and the manufacturer's recommendations. Give special attention to supply air diffusers and grilles in laboratory areas. Refer to latest ASHRAE Application Handbook chapter on laboratories.

B. Base selection on air flow, noise criterion (NC) level, air pattern, throw, mounting height, face velocity, pressure loss, aesthetic, etc., requirements.

C. Provide an integral opposed-blade damper only when a manual-balancing damper cannot be installed in the branch duct.

D. Provide drainable blade louvers with bird-screen for outside air intake and discharge louvers to provide proper drainage of snow and rainwater.

1. Louvers shall bear the AMCA Seal with ratings based on tests and procedures performed in accordance with AMCA Publication 511. The

AMCA Certified Rating Seal applies to air performance and water penetration ratings.

E. Connect outside air ducts for building makeup air systems directly to a fan system. Do not use mechanical rooms as air plenums.

F. Provide flexible connections immediately adjacent to the suction and discharge ends of moving equipment, e.g., fans, AHUs, etc.

G. Construct exhaust systems with materials suitable for service, e.g., stainless steel, non-galvanized, etc. Ducts handling high abrasive or corrosive materials shall be sufficiently resistant to same.

H. Route trunk ductwork parallel to building walls to conserve ceiling space and allow for future utilities.

I. Provide an airflow indicator for new or modified fume hoods and other local exhausts such as welding bench hoods, etc. See Mechanical Standard Drawing(s) ST-D3040-1 for installation details on a hood static pressure gage.

J. Paint visible interior duct surfaces behind air terminal units flat black as required where reflection (dark rooms), or aesthetics is a concern.

## 25.0 HVAC—DUCT LINING

A. Limit the use of duct lining as much as possible (due to potential IAQ issues). Document justification for its use. If its use is justified, limit to the following:

1. As an acoustical liner to absorb unwanted crosstalk, equipment, and air rush noise.

2. As an insulator when ductwork is located outdoors and requires insulation, but exterior insulation is not practical.

## 26.0 HVAC—FANS

A. Select fan so that its minimum operating point, such as minimum airflow for VAV systems, falls on the negatively sloping portion of the pressure curve to prevent surging or pulsation.

B. Carefully analyze system effect in fan sizing to minimize a “derating” of the HVAC system fan. Refer to SMACNA HVAC Systems Duct Design Manual.

## 27.0 HVAC—FILTERS FOR HVAC SYSTEMS AND HEPA EXHAUST SYSTEMS

A. HVAC Systems

1. Pre-Filter: Provide a Minimum Efficiency Reporting Value (MERV) #8 filter, per ASHRAE Standard 52.2, unless usage of space dictates a higher efficiency and class of filter.[35]

2. Exhaust restrooms and janitor’s closets at a rate of not less than that specified in ASHRAE Standard 62.1.

[35] Filter class per ASHRAE Handbook HVAC Systems and Equipment, 2024

## 28.0 HVAC—SUPPLY AIR INTAKES

A. Locate intakes at least 24 inches above grade to prevent intake of snow.

# Chapter 7 ELECTRICAL

## 1.0 SITE-SPECIFIC REQUIREMENTS

A. Elevation Effects

1. Diminished dielectric strength of air
   a. Use 600V contacts for 480V power circuits
2. Provide medium-voltage equipment with a BIL of 110kV (at sea level) to achieve a BIL of 95kV at 7500 feet.
3. Diminished cooling
   a. Must derate equipment accordingly

B. Solar heat gain = 110 W/ft$^2$ (direct sunlight)

C. Lightning protection

1. If structure houses explosives, lightning protection is required
2. For all other structures, perform calculations per NFPA 780 Annex L. If these calculations recommend lightning protection, LANL requires it.
   a. Ground strike rate: 3 / km$^2$ / year

D. When determined to be required, provide lightning protection systems in accordance with NFPA 780*, Standard for the Installation of Lightning Protection Systems*; UL 96A, *Installation Requirements for Lightning Protection Systems*; and Lightning Protection Institute (LPI) Standard LPI-175, *Standard for the Design – Installation – Inspection of Lightning Protection Systems*. Soil Rho: 225 $^o$C-cm/W.

E. Ambient earth temperature of 20°C (68$^o$F) outside the perimeter of a heated building.

F. Ambient earth temperature of 30°C (86$^o$F) inside the perimeter of a heated building.

G. Utility: 15kV distribution system[36] The 15kV distribution system is the responsibility of LANL-UI.

1. To obtain available fault current: faultcurrent@lanl.gov
2. Service point is as follows:
   a. Pad-mount transformer: at the secondary lugs of the utility transformer, unless otherwise indicated by LANL-UI0001.

[36] Substation transformers that supply the medium voltage distribution system have 13.8 kV secondaries. Utility transformers that are connected to this distribution system, for supplying facilities, have 13.2 kV primaries.

b. Pole mount transformer or transformer bank: The splices that are immediately outside the weatherhead, unless otherwise indicated by LANL-UI.

H. Provide door-in-door panelboards.

I. Install labels on receptacles and light switches indicating circuit number and panelboard.

J. Rodent proofing.

1. Seal all cable entries and plug unused conduits entering outdoor equipment with material that rodents will not be able to gnaw through, squeeze through, or push side. *Suitable materials include 24-gauge or heavier galvanized sheet steel, 19-gauge galvanized woven/welded 1/4" mesh hardware cloth, 16 to 19-gauge stainless steel 1/4" mesh hardware cloth, and galvanized lath screen.*

2. When penetrating an exterior wall, roof, or floor with conduit, wireway, enclosed busway, etc., seal openings and provide a metal collar securely fastened to the structure.

3. Seal all cable entries and plug unused conduits entering indoor equipment from outdoors with material that rodents will not be able to gnaw through, squeeze through, or push aside. Suitable materials include 24-gauge or heavier galvanized sheet steel, 19-gauge galvanized woven/welded 1/4" mesh hardware cloth, 16-19-gauge stainless steel 1/4" mesh hardware cloth, and galvanized lath screen.

K. Buck/Boost transformers may only be used with the permission of the electrical standards point of contact.

L. Feed buildings with 480/277 volts.

1. Use multiple small transformers (75kVA or less) for interior power distribution.

a. 75 kVA transformers have small amounts of available fault current and result in incident energies less than 1.2 cal/cm$^2$.

2. Larger transformers may be used with the permission of the electrical standards point of contact.

3. Supplying the facility with 480/277 also allows the option of using transformers with a European secondary, 400/230, for the powering of special equipment.

M. UPS installations

1. Supply batteries that are plug-in instead of wired terminals.

2. Power input to external maintenance bypass switch must be transformer isolated to prevent bonding issues.

3. System Bonding Jumper must be in the external maintenance bypass switch only. The UPS itself and the Bypass Transformer must not have a system bonding jumper. The UPS and the Bypass transformer must have

a label applied stating “No system bonding jumper at this location. System bonding jumper is in external maintenance bypass switch”.

N. Identification and labelling

1. Provide engraved laminate nameplates on all equipment.
2. Provide incident energy information per NFPA 70E, *Standard for Electrical Safety in the Workplace.*

O. Separately derived system

1. System bonding jumper must be installed at transformer location instead of first disconnect.

P. Trenches for Electrical Systems

1. Utility Duct Banks (15kV)
   a. Concrete-encase duct banks in trenches and include a 4/0 bare copper conductor within it.
2. Low Voltage Trenches (Electrical Power 600 volts and below)
   a. Concrete encasement is not required, and a 4/0 bare copper conductor must not be installed.
   b. Warning tape must be place in the trench, at least 12 inches above the duct bank and at least 6 inches below grade.
3. Telecommunications Trenches
   a. 4/0 bare copper conductor must be run.

Q. Locations above 40cal/cm$^2$:

1. Provide remote operation of circuit breakers.
   a. Plug-in umbilical cord or pendant
   b. Remote control panel
2. Provide permanently mounted absence of voltage tester (e.g., Graceport test point) on the line- and load-side of OCPD[37] in these locations.

R. Use equipment listed by a NRTL[38], where available. Unlisted equipment, if it contains an electrical circuit over 50 VAC or 100 VDC, must be approved by the AHJ before use.

S. Use IEEE-841[39] motors whenever possible.

T. Enclosed offices, conference rooms, and similar interior spaces: Provide one receptacle outlet on each wall plus additional receptacle outlets so no point measured horizontally on any wall space is more than 6 ft from a general-

[37] Overcurrent Protection Device. Either Circuit breaker or set of fuses
[38] Nationally Recognized Testing Laboratory. E.g. UL, FM, TUV, CSA
[39] Motor standard developed for the petroleum and chemical industries. IEEE-841 motors have an external ground lug on the frame, better vibration characteristics, more robust bearings, better Ingress Protection characteristics, more accurately milled frames for alignment concerns, and are inverter duty (for VFDs).

purpose receptacle outlet. In no case shall there be more than 8 devices per circuit that supplies receptacles.

## 2.0 SUSTAINABILITY

A. Provide remotely monitored (e.g., SCADA, EES, or BAS) metering for electrical service when structure > 5,000 $ft^2$.

1. Follow ESM Ch. 14 Attachment 2 - Utility Metering Requirements and contact umetering@lanl.gov for specifications on type of meter.

B. Use LED lighting

1. Design facility to comply with applicable energy codes and Federal Purchasing Requirements, including FEMP designated products.

# Chapter 8 INSTRUMENTATION & CONTROLS (I&C)

## 1.0 BUILDING AUTOMATION REQUIREMENTS (I&C):

A. Provide a LANL yellow network connected building automation system (BAS) for new and existing facilities as follows:

1. Any air-conditioned facility > 5,000 $ft^2$
2. Modifications to facilities with an existing BAS
3. In buildings less than 5,000 $ft^2$, when complexity of system (e.g., VAV), accuracy (e.g., tight temperature control not more than +/-1 deg F), or energy payback justifies cost.

B. The BAS shall be of the brand and manufacturer stated in LANL Master Specification Section 25 5000 with no substitutions allowed.

C. Equipment protection safeties must be hard-wired to provide protection for the following (see LANL Master Specification Section 25 5911):

1. Freeze protection of water coils and/or water filled systems.
2. High/low duct pressures that can damage ductwork or building structures.
3. Fire alarm shutdown when required by code.
4. Other safeties needed, not provided as part of the HVAC equipment, that protect equipment, property, or personnel.

D. Control cabinets used for BAS shall:

1. Be designed to contain voltages no greater than 50V.
2. Be shown on floor plans.
3. Have power sources dedicated to BAS, if power is not supplied by the controlled HVAC equipment.

E. BAS power sources shall be of the NEC Class 2 type, and use resettable breaker protection if providing greater than 40VA. Reset shall be accessible without exposing voltages greater than 50V.

F. When using HVAC packaged or skid-mounted equipment with integral controls, the Engineer of Record must show proof that acceptable integration with the BAS can be accomplished during Title II review (see ESM Chapter 8, 5.3.D for acceptable means to accomplish this).

G. Special systems that must be monitored and generate alarms upon detection of failure by the BAS include, but are not limited to:

1. Heat trace systems for freeze protection
2. Server and equipment room temperatures
3. Water coil freeze protection circulation pumps
4. Other systems, where undetected failure can cause significant damage to facilities or programs

H. Sensors connected to the BAS must be adequate to remotely monitor and diagnose controlled equipment failures and shall include:

1. Temperature change sensing of heat/cool producing devices (e.g., coils)
2. Analog current sensors for the detection of operations for motors (e.g., fans, pumps)
3. Alarm contacts from non-HVAC internal system controls (e.g., an air dryer)
4. VFD internal signals using network connections (i.e., BACnet MSTP).

I. Networks used for controller-to-controller or controller-to-equipment shall use ASHRAE BACnet MSTP or BACnet Arcnet for communications. Network connections shall not be used to directly control major equipment; use hard-wired points for such.

J. Implement night-setback in all BAS control systems, independent of whether it is required for the current application. It may be disabled for 24/7 applications but must be easily re-enabled when needed.

K. Follow requirements of Sections in Div 25 of the LANL Master Specifications for BAS installations, edited to the project requirements.

L. Hazard Control Systems: Processes or operations that involve significant hazards shall be evaluated though an HAZOP process. If protection required to mitigate the hazards to an acceptable level includes the use of a safety instrumented system (SIS), such as for ML-3, design per ESM Ch. 8. These may include, but are not limited, to these hazard categories (HCs): Accelerator, Biological, Chemical (4 levels), Explosives, Firing Range, or Nature of Process (with otherwise being “Standard Industrial Hazard,” which means under the thresholds in Figure A-1 of DOE-HDBK-1163-2020, *Integration of Hazards Analyses*). These HCs are defined by LANL SBP111-1 (internal link).

## Chapter 9 SECURITY

Follow ESM Chapter 9 and associated LANL Master Specifications and Std. Details; DOE O 473.1A Attachment 1 CRD, *Physical Protection Program* is mandatory.

## Chapter 10 HAZARDOUS PROCESS

Follow ESM Chapter 10 when hazardous materials will be used in the structure.

## Chapter 11 RADIATION PROTECTION

N/A, out of scope.

## Chapter 12 NUCLEAR

N/A, out of scope.

# Chapter 13 WELDING, JOINING, & NONDESTRUCTIVE EXAMINATION (NDE)

## 1.0 WELDING GENERAL

A. Welding, joining, and NDE design, detailing, and work activities must comply with the codes and standards established by EOR (Engineer of Record) based on Chapter 1 herein.

B. For offsite welding, design shall require compliance with the requirements of LANL Master Specification (LMS) Section 01 4444.

C. For onsite welding, design shall require compliance with the requirements of LMS Section 01 4455.

1. Exceptions for Subcontractors (i.e., use of these LANL processes is optional; however, Subcontractor must submit evidence of satisfactory processes and qualifications as required by 01 4455):

a. use of LANL's Welding Checklist

b. demonstration of welding/brazing skill by test at LANL, and LANL certification.

c. following LANL's filler material control approach (instead, follow 3.0.B below).

*Note: The Sections above help to ensure that submittals required for IBC Ch. 17 Special Inspection reviewers, and ASME B31 piping, are available in the LANL records systems.*

## 2.0 WELDING – DESIGN AND CODE COMPLIANCE

A. Welding Symbols and Joints

1. Utilize AWS A2.4 for welding symbols and AWS A3.0 for standard welding terms and definitions.

## 3.0 PROJECT PLANNING AND EXECUTION (WELDING AND NDE)

A. Early Planning Guidance

1. Develop a comprehensive welding plan during the early phases of the project, addressing:

a. Required welder and inspector qualifications

2. Procurement of filler metals and consumables

3. Equipment needs

4. WPSs that cover all base metals and weld processes planned for project.

5. Scheduling of welding activities

6. Storage and issue requirements of welding filler materials

7. Quality control measures

8. NDE requirements.

B. Procurement and Control of Filler Materials

1. Specify and procure in accordance with project requirements.
2. Implement proper storage and handling procedures.
3. Control materials, limiting access only to trained and approved personnel.
4. Verify proper filler materials as listed on selected WPS before use.

C. Quality Control

1. Establish hold points for inspection and verification of welding activities.

*Guidance: It may be beneficial for parties with QA responsibilities to conduct regular audits of welding activities to ensure compliance with procedures and standards.*

## 4.0 NONDESSTRUCTIVE EXAMINATION (NDE)

A. All NDE shall be performed by service providers listed on the LANL LBO Approved Listing.

1. If the desired NDE service provider is not listed, ensure that the NDE POC (noted in listing p. 1) is contacted early in the project to perform the assessment.
   a. Assessment is based on ASTM E543.
   b. ISO 17025 or Nadcap certification for a given location normally qualify an organization for listing in lieu of a full assessment. Other national or international certification will be considered on a case-by-case basis.

B. Require the following in the Specification as submittals (LMS 01 4525 is a good template) and review promptly and carefully to ensure that project complies:

1. Verify the practice for qualification and certification of personnel meets the code or standard requirement, typically ASNT SNT-TC-1A.
2. Ensure that all personnel are properly qualified and certified in accordance with the practice above, including current visual acuity.
3. Ensure NDE procedures are reviewed and approved by the service provider Level III before use
4. Obtain/review examination reports in a timely manner, signed and dated by appropriately certified personnel.
5. For final project record, procedures, personnel certification records, and test reports must be appropriately organized and transmitted to LANL.

C. Methods

1. Specify appropriate NDE methods based on code requirements and project specifications. Guidance: Common methods include visual inspection, radiographic testing, ultrasonic testing, magnetic particle testing, and penetrant testing. Given the wide variety of capabilities of the different NDE methods, and particularly the techniques within those methods, it is strongly suggested to consult the LANL NDE SME to

determine the appropriate method and specific technique if it is not explicitly stated by the Code or Standard.

# Chapter 14 SUSTAINABLE DESIGN

Exceptions, clarifications, and guidance (including its References and Resources) — and abbreviations & definitions not in the Conduct of Engineering Glossary — may be found in ESM Chapter 14 and utilized here*. There may be additional exclusions and exceptions not contained there, so consulting the Chapter POC is also highly recommended.*

## 1.0 PRODUCT SPECIFICATION AND PROCUREMENT

A. When specifying and procuring products or services for construction, compliance with the following statutory programs is required:

1. EPA Comprehensive Procurement Guidelines (CPG) Program
2. USDA BioPreferred ® Program
3. ENERGY STAR® Program or Federal Energy Management Program (FEMP)
4. EPA SNAP Program.

B. When both an EPA-designated item and a BioPreferred item could be used for the same purposes, and a product that meets both is not available, select the EPA-designated item.

C. If a product or service cannot be obtained due to any criteria below, then project may submit a written justification to seek exemption from the statutory program requirements.[40]

1. not available within a reasonable schedule,
2. unreasonable price (initially over 10% more, or higher life-cycle cost), or
3. fails to meet reasonable performance requirements.

For further guidance on product categories see ESM Chapter 14, Attachment 1 and *https://sftool.gov/greenprocurement*.

## 2.0 BUILDING DESIGN

A. The required energy efficiency standard for all projects is ASHRAE 90.1-2019.

B. New construction (buildings and additions of all sizes) to meet Federal energy efficiency standards.

1. Meet ASHRAE 90.1-2019 and, if life cycle cost effective, achieve energy consumption levels at least 30% below ASHRAE Baseline Building 2019. If 30% reduction is not life-cycle cost effective (LCCE), modify building design to achieve the highest level of energy efficiency that is LCCE.
2. Calculations shall include the building envelope and energy consuming systems as specified by ASHRAE 90.1 (e.g., space heating/cooling,

[40] Per FAR Clause 23.103(a)(2)). For approval, contact Contracting Officer (LANL ASM Procurement Specialist) for C.1 or C.2, and applicable Standards POC for C.3.

ventilation, service water heating, lighting and all receptacle and process loads, except for energy-intensive process loads that are driven by mission and programmatic/operational requirements).

3. Determine energy consumption for both the ASHRAE Baseline Building and proposed building using the Performance Rating Method (Appendix G, ASHRAE 90.1). Provide LANL with the ASHRAE Std. 90.1 Performance Based Compliance Form at 30% design completion. Calculate the percentage of improvement shall as follows:

   Percentage improvement = 100 x (1-PCI/PCIt), where:

   PCI = Performance Cost Index calculated per (90.1-2019, Section G1.2)

   PCIt = Performance Cost Target calculated by formula in (90.1-2019, Section 4.2.1.1)

4. When energy consumption (all sources) is less than 12.7 kBtu/GSF/yr, ASHRAE Performance Rating Method modeling is not required. However, a simple calculation estimating annual energy use shall be provided by 30% design completion to LANL Utility Resource Management and Mechanical SMEs for concurrence. Provide a COMCheck report by 90% design completion to these same LANL SMEs demonstrating compliance with mandatory provisions of ASHRAE 90.1-2019. No documentation of any kind is needed for facilities without external power or only lighting.

C. Buildings, including additions, larger than 5,000 gross square feet shall:

1. Meet 18 core and 9-out-of-12 non-core criteria from the latest Guiding Principles for Sustainable Buildings (GP) or successor and accomplish performance tracking and reporting to Chapter 14 POC/SME. If a specific criterion is deemed not LCCE, LCC calculations are required, and performance tracking and reporting is still required. Buildings are exempt from this requirement if they are to be unoccupied, to use less than 12.7 kBtu/GSF/year total energy usage from all sources, and to use less than an average of 2 gal/day of water.

D. For new buildings with a total project cost greater than that identified in TSM Attachment 1 (approximately $3.9M) follow ESM Chapter 14 and any variances posted with it regarding Limiting On-site Fossil Fuel-Generated Energy Consumption (e.g., VAR-10727).

E. New buildings, or buildings which are part of a phased project, with total estimated cost greater than $50M, shall:

1. Meet or exceed U.S Green Building Council LEED (v4 or later) Gold certification unless an approved waiver from the NNSA Project Management Executive is obtained through the formal process. Parking structures, exclusively process and power-generating buildings, and distribution systems are exempt.

2. The design agency is responsible ensuring that LEED Minimum Project Requirements are met, and for registering, submitting documentation, and

ensuring certification through GBCI including costs related to registration and certification.

3. If over 25,000 GSF, be designed to operate without producing greenhouse gas emissions, and designed to minimize water use and waste from building operations.

F. For laboratories, follow ESM Chapter 14 requirements for same.

G. Remodels, Renovations, and Modernizations

1. Follow the same criterion as new buildings in sections 2.0.B–D above.

2. Exception: Renovations and building alterations (including new systems and equipment) below the cost and size limits defined in sections 2.0.B–D above must meet ASHRAE 90.1-2019. A “change in space conditioning” or “change of occupancy or use” which results in an increase in demand for energy must follow ASHRAE 90.1-2019 Section 4.1.1.5.

3. Sum costs of subsequent, sequential remodel, renovation, and modernizations to determine applicability of fossil fuel-generated energy requirement. Consult ESM Ch. 14 and any amendments (e.g., VARs) for additional requirements.

# Chapter 15 COMMISSIONING

## 1.0 GENERAL

*Guidance: LANL will self-perform or contract with an experienced commissioning (Cx) provider (commissioning agent, CxA) who is independent of the project design, construction, and operations team. The CxA will direct commissioning tailored to the size, complexity, and management level of the building and its system components in order to optimize and verify performance of building systems in accordance with this chapter.*

## 2.0 DESIGN AGENCY REQUIREMENTS

A. Develop clear and concise system descriptions and test-acceptance criteria (e.g., ranges, tolerances) and include in the construction documents such that commissioning plans and acceptance procedures can be developed and executed.

B. Include in project equipment specifications requirements for

- equipment startup to be provided by manufacturer's qualified representative as required.
- submittals from manufacturers for installation, operations, and maintenance data on equipment as required.
- vendor provided training on equipment to LANL operations and maintenance personnel as required.

C. Develop a commissioning specification section for inclusion in the design package. LANL Master Specification Section 01 9100, *Commissioning* includes the minimum requirements, including Constructor role during Cx.

D. Develop a TAB specification section for inclusion in the design package. LANL Master Specification Section 23 0593, *Testing, Adjusting, and Balancing for HVAC* includes the minimum requirements.

E. Provide technical support during Title III to resolve test deficiencies found during the acceptance testing phase of the project. This may include serving as the subject matter expert in approving the LANL test deficiency report forms.

# Chapter 16 BUILDING CODE PROGRAM

## 1.0 BUILDING DEPARTMENT

Because LANL is an autonomous jurisdiction, including permitting authority (e.g., LANL Building Official/LBO and other AHJs), LANL processes for design review, permitting, inspection, and certificate of occupancy shall be followed; LANL STR or project engineer will broker/handle all code official interactions.

## 2.0 DESIGN PROFESSIONAL IN RESPONSIBLE CHARGE (DPIRC) DUTIES

A. Design structures, systems, and components (SSCs) per the 2021 International Building Code (IBC) and other codes and standards listed and amended by ESM Chapter 16 Section IBC-GEN Attachment A LANL Building Code (LBC), exclusive of the NMAC. The expected life span of new permanent facilities at LANL is 30–50 years, assuming regular maintenance and periodic system replacements during that time; design accordingly.

B. Existing SSC modifications shall follow the 2021 International Existing Building Code (IEBC) as amended by ESM Chapter 16 Section IBC-GEN Attachment B LANL Existing Building Code (LEBC).

1. LANL-internal project scoping: Prior to performing significant renovation work on facilities, follow NIST GCR 11-917-12/ICSSC RP 8 (or DOE-mandated successor) to determine whether a seismic evaluation is necessary. If evaluation is necessary, use RP 8 to establish the associated requirements, as well as mitigation requirements (if the evaluation indicates such is required).

C. Sign the Registered Design Professional in Responsible Charge Designation form acknowledging IBC-related duties as same (ESM Ch. 16 IBC-GEN FM03).

D. Develop statement of special inspections (SSI) when required by IBC 1704.3; see ESM Chapter 16 Section IBC-IP for acceptable template.

E. Submit IBC-required structural observations to the LANL Lead Chief Inspector. Structural observations are the responsibility of the structural engineer of record (EOR) unless otherwise stated in the Subcontract. EOR must subcontract observations if he/she is in the same company as the prime Subcontractor, and LBO must approve observation performance by persons other than the structural EOR.

F. Submit any revised occupancy or use categories [and IEBC alteration level(s) for existing building modifications] through LANL Project personnel.

G. Delegated design: The DPIRC is ultimately responsible for delivering all engineering products required by the ESM/Subcontract to the LBO, even those specialties that are delegated [exception: design by constructing firm's subtiers (e.g., fire protection), in which case such design is accepted by DPIRC]. When DPIRC is retained for engineering services during construction (aka Title III), this includes managing change control, as-built construction documents (where required by contract), etc.

H. Design revision after permitting: Permitting authority re-approval via project engineer is required when the changes (a) do or could affect code compliance including but not limited to fire, structural, life safety, and/or egress or (b) increase the scope.

## 3.0 CONSTRUCTION SUBCONTRACTOR DUTIES

A. Produce and submit a test and inspection plan (TIP); see ESM Chapter 16 Section IBC-IP for acceptable template.

B. For approval of offsite fabricators to perform certain structural safety affecting work without in-shop special inspection/expense being necessarily external to the firm per IBC Ch. 17, follow ESM Ch. 16 Section IBC-FAB *Offsite Structural Fabricator Approval Process*. (Existing LBO-Approved firms are here.) Submit any requests to LANL STR; Chief Inspector requires two (2) weeks lead time. When LBO-approved fabricator is utilized, submit Offsite Structural Fabricator Certificate of Compliance (IBC-FAB Att B).

C. Ensure only LBO-approved third-party testing agencies are used (listing on ESM Ch.16). If preferred testing agencies are not on the approved list, subcontractor may submit the necessary data for evaluation (see ESM Ch. 16 Section IBC-TIA). Chief Inspector requires two (2) weeks lead time.

D. Begin work when authorized. Construction work including offsite structural element fabrication work must not start until authorized by the LANL Building Code Program after evaluating that the project has complied with all necessary IBC and program requirements. (Exceptions: grading, excavation, storm water protection, or D&D not affecting life safety/egress or requiring design may proceed).

*Note: Only the LANL code permitting authority may authorize construction-at-risk, or procurement involving submittals or inspection, with sufficient justification.*

E. Constructors must follow the approved inspection plan(s) and, where applicable, Subcontractors submit ESM Chapter 16 Section IBC-IP Att H “Subcontractors Statement of Responsibility (with respect to Special Inspection)”.

# Chapter 17 PRESSURE SAFETY

A. Pressure systems in the scope of the pressure safety program shall follow the requirements of this chapter. See P101-34, Pressure Safety, Section 3.2 "Pressure Systems (and Exclusions)" for the definition of a pressure system and types of piping systems considered excluded from the program. (Link is LANL internal only; document or excerpt will be provided upon request to STR.)

B. Comply with the latest edition as the ASME design basis:

1. American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code
    a. Section I, Rules of Construction of Power Boilers
    b. Section II—Materials, Part A—Ferrous Material Specifications (Beginning to SA-450)
    c. Section II—Materials, Part A—Ferrous Material Specifications (SA-451 to End)
    d. Section II—Materials, Part B—Nonferrous Material Specifications
    e. Section II—Materials, Part C—Specification for Welding Rods; Electrodes, and Filler Metals
    f. Section II—Materials, Part D—Properties (Customary)
    g. Section II—Materials, Part D—Properties (Metric)
    h. Section IV, Rules for Construction of Heating Boilers
    i. Section V, Nondestructive Examination
    j. Section VIII, Division 1, Rules for Construction of Pressure Vessels
    k. Section VIII, Division 2, Rules for Construction of Pressure Vessels, Alternative Rules
    l. Section VIII, Division 3, Rules for Construction of Pressure Vessels, Alternative Rules for Construction of High Pressure Vessels
    m. Section IX—Welding, Brazing and Fusing Qualifications, Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators
    n. Section X, Fiber-Reinforced Plastic Pressure Vessels
    o. Section XII, Rules for Construction and Continued Service of Transport Tanks
2. ASME B31 piping codes
    a. B31.1, Power Piping
    b. B31.3, Process Piping

c. B31.5, Refrigerant Piping

d. B31.8, Gas Transmission and Distribution Piping Systems

e. B31.9, Building Services Piping

C. ASME alternatives in the ESM are similarly allowed for TSM systems.

*Guidance: ESM Chapter 17, Pressure Safety contains additional information that can aid a pressure system Designer in designing a pressure system that complies with an ASME or non-ASME design basis.*

*In addition, the LANL Master Specifications (LMS) relating to pressure systems generally provide a work result that meets code. In particular, Section 01 4115* Pressure Safety Submittals *will ensure compliance evidence is received, and it is referenced by many of the LMS pressure system sections in Div 02-43. Likewise, 01 4631,* Welding, Brazing and Soldering of ASME B31 Piping *and 01 4731,* Flange Assembly ASME B31 Systems*.*

# Chapter 18 SECURE COMMUNICATIONS

Follow ESM Chapter 18 when this is applicable.

# Chapter 19 COMMUNICATIONS

Follow ESM Chapter 19. Paging system only required when indicated in the SoW.

# Chapter 20 SYSTEMS ENGINEERING

This chapter only applies to projects with Total Project Cost (TPC) of $34[41] million or more. Such projects shall apply a systems engineering approach commensurate with the risk, rigor, and extent of the project's programmatic and functional requirements.[42] *Projects $20 – $34 million are recommended to incorporate elements of systems engineering (SE)*.

*Note: Engineering requirements are defined as requirements that the project, in agreement with the project customer, has delegated to engineering, ensuring that requirements are verified at the end of the project. Engineering requirements include requirements decomposed and derived from delegated requirements.*

A. The Design Agency shall support LANL's SE effort by performing A.1-3 below.

1. Provide a description of Design Agency's approach to the following SE tasks prior to the end of conceptual design.
2. Provide designs and, as appropriate, perform activities linked to and satisfying engineering requirements; contribute to LANL's crosswalk for same in Para C.6 below. See also Paras C.2. and C.5.
3. Provide testing, inspection, and commissioning requirements linked to and verifying engineering requirements, including through any design revisions/changes. See Paras C.4 and C.5.

The remainder of this chapter is LANL responsibilities.

B. Planning

1. Describe the SE approach in a plan[43] subject to approval by LANL Project Engineering Management or delegate (e.g., PIE-3). Projects should consult the Chapter 20 POC for review.
2. Describe interface management by engineering in an Interface Control Document(s) (ICD). Engineering shall identify engineering and other technical interfaces in the ICD(s) by the end of conceptual design and revise the ICDs by the end of the preliminary design. *The ICD(s) should be revised at major milestones after preliminary design*.
3. Use an SE tool [e.g., Magic Cyber Systems Engineering (nee Cameo)] when TPC is $50 million or more. *Projects below this threshold should consider its use.*

C. Engineering requirements shall be established and documented in a requirements document subject to approval by LANL Project Engineering Management or delegate (e.g., PIE-3).

1. The engineering requirements shall address the physical and functional requirements of the SSCs (key performance parameters), programmatic

[41] At time of writing, $34M is the minor construction threshold and therefore subject to NNSA SD 413.3-7. See TSM Attachment 1 for latest lower threshold for chapter.
[42] As guidance for this chapter (and for projects beyond the scope of the TSM), refer to ESM Chapter 20.
[43] For simpler projects, this might be addressed in the PEP; for complex ones, a standalone SEP is likely appropriate.

and operational requirements, interface needs, and requirements found in the requirement documents or other sources.

*Note: See ESM Chapter 20 for a comprehensive list of potential documents. Requirement source types may exist in different forms and engineering judgement should be used when determining whether requirement sources or requirements themselves are pertinent.*

2. Requirements shall be written in accordance with ISO 29148, *Systems and software engineering – Life cycle processes – Requirements engineering*, Section 5.2, Requirements Fundamentals.[44]
3. Engineering requirements shall be satisfied by design outputs and/or design-phase activities. LANL personnel must satisfy those requirements outside the responsibility of the Engineer of Record.
4. Engineering requirements shall be traced to higher-level programmatic and functional requirements.
5. Engineering requirements shall be verified and reflected in project records.
6. Provide documentation of traced, satisfied, and verified requirements. Such may be organized in separate matrices — a Requirements Traceability Matrix (RTM), Requirements Satisfaction Matrix (RSM), and Requirements Verification Matrix (RVM) — or a combined matrix (see Figure 20-1 below).
    i. Matrix(ces) shall include engineering requirements verbatim.
    ii. RTM shall include a rationale for the engineering requirement, and each shall be traced to documents archived in approved document databases (e.g., EDRMS). *RTM should include defining the responsible owner of specific requirements.*
    iii. RSM(s) shall be related to design documents (e.g., drawings) satisfying the engineering requirements in approved document databases, and updated at each design review. *RSM(s) should be completed when the design phase is complete.*
    iv. RVM shall be related to objective evidence (e.g., record drawings, testing in approved document databases) verifying the engineering requirements.

[44] In addition, INCOSE-TP-2010-006-04| (VERS/REV:4 | 1 July 2023) *Guide to Writing Requirements* provides expanded guidance on the practice of requirements management and writing.

| Req't ID | Requirement | Rationale | Owner | Traced From | Satisfied by | Verified by |
|---|---|---|---|---|---|---|
| [Unique No.] | [Engineering requirement for which engineering is responsible] | [Reason the requirement was established and is needed] | [Organization(s) or position(s) that has authority over requirement] | [Document that results in (drives) the engineering requirement] | [Design document that portrays how the requirement will be fulfilled] | [Objective evidence that shows that the system fulfills the requirement] |

Figure 20-1 Traceability/Satisfaction/Verification Requirements Matrix (TSVRM) (Sample)

# Chapter 21 SOFTWARE

A. For all SSC software (controls hardware real-time), provide listing of such locations/usage to LANL (who will handle all required LANL software quality program expectations for ML-4 software).

B. For ML-3 or higher software (e.g., certain high-value, security, or environmental implications of failure beyond typical commercial), perform the following:

1. When providing designs that involve software, associated software must be identified, categorized, and quality controlled at the appropriate stages in the design process.

- For SSC software (including reconfigurable firmware), subcontractor shall serve as the software owner (SO) up to the point of turnover. Upon turnover, transfer SO responsibility to LANL system engineer by way of the STR. (Note: The FDAR is the responsible manager throughout the software life cycle, however, may delegate Owner activities during development and implementation to the Design Agency or Constructor.)

## Appendix and Attachment

Appendix A - Documents Implemented by the TSM

Attachment 1- Cost Escalations

# APPENDIX A: DOCUMENTS IMPLEMENTED BY THE TSM

For basis purposes, this appendix documents the mandates that will be inherently satisfied when the TSM is followed but does not impose them on the TSM user (i.e., expect them to be followed directly) unless they are specifically required by the SoW or a chapter herein.

A project-specific code of record (COR) listing is required from Design Agency and should include the key, applicable regulations (CFRs), codes, and standards listed below or derived from them. In addition, the listing can indicate which DOE mandates were satisfied without depicting them as part of the COR per se (e.g., as “Other Documents Implemented”).

CFRs including but not limited to

A. 10 CFR 433, *Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High-Rise Residential Buildings*

B. 10 CFR 436, Subpart A, *Methodology and Procedures for Life Cycle Cost Analysis*

C. 10 CFR 851, *Worker Safety and Health Program*

D. 29 CFR 1910, *Occupational Safety and Health Standards*

E. 29 CFR 1926, *Safety and Health Regulations for Construction*

LANL/NNSA Prime Contract

All aspects including Appendix B listing of required DOE/NNSA directives

DOE/NNSA Orders and Standards

A. DOE O 413.3B, Chg. 7, *Program and Project Management for the Acquisition of Capital Assets*

B. DOE O 414.1E, *Quality Assurance* (Contractor Requirements Document CRD only)

C. DOE O 420.1C, Chg. 3, *Facility Safety* (CRD’s Chapters II–Fire Protection and Chapter IV–Natural Phenomena Hazards Mitigation)

D. DOE-STD-1020-2016, *Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities*

E. DOE-STD-1066-2016, *Fire Protection*

F. NNSA SD 413.3-7, *Project Management for Non-Nuclear, Non-Complex Capital Asset Acquisition*

G. NNSA SD 430.1, *Real Property Asset Management* (and thus DOE O 430.1)