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Sandia National Laboratories SNL/CA Facilities Management Design Standards Manual

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Sandia National Laboratories

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Change Log

Rev	By	Date	Type	Change Description	Pages
0	David Rabb/Eva Clark	11/15/2014	New	Initial Issue	All

Acronyms

Acronym	Definition
CA	California
MAN	Manual (a SNL/CA Facilities Management document)
NM	New Mexico
SNL	Sandia National Laboratories

1.0 Introduction

1.1 Document Purpose

At Sandia National Laboratories in California (SNL/CA), the design, construction, operation, and maintenance of facilities is guided by industry standards, a graded approach, and the systematic analysis of life cycle benefits received for costs incurred. The design of the physical plant must ensure that the facilities are "fit for use," and provide conditions that effectively, efficiently, and safely support current and future mission needs. In addition, SNL/CA applies sustainable design principles, using an integrated whole-building design approach, from site planning to facility design, construction, and operation to ensure building resource efficiency and the health and productivity of occupants. The safety and health of the workforce and the public, any possible effects on the environment, and compliance with building codes take precedence over project issues, such as performance, cost, and schedule.

These design standards generally apply to all disciplines on all SNL/CA projects. Architectural and engineering design must be both functional and cost-effective. Facility design must be tailored to fit its intended function, while emphasizing low-maintenance, energy-efficient, and energy-conscious design. Design facilities that can be maintained easily, with readily accessible equipment areas, low maintenance, and quality systems. To promote an orderly and efficient appearance, architectural features of new facilities must complement and enhance the existing architecture at the site. As an Architectural and Engineering (A/E) professional, you must advise the SNL/CA Project Lead (either a Project Manager on large Complex Capital Projects or a Project Lead, for smaller/faster/less complex or single discipline projects) when this approach is prohibitively expensive. Whenever seen in this Manual, the role of Project Manager or Project Lead is to be viewed as interchangeable.

You are expected to use professional judgment and ingenuity to produce a coordinated interdisciplinary design that is cost-effective, easily contractible or buildable, high-performing, aesthetically pleasing, and compliant with applicable building codes. Close coordination and development of civil, landscape, structural, architectural, fire protection, mechanical, electrical, telecommunications, and security features is expected to ensure compatibility with planned functional equipment and to facilitate constructability. If portions of the design are subcontracted to specialists, delivery of the finished design documents must not be considered complete until the subcontracted portions are also submitted for review.

You must, along with support consultants, perform functional analyses and programming in developing design solutions. These solutions must reflect coordination of the competing functional, budgetary, and physical requirements for the project. Depending on the graded approach, during design phases, meetings between you and the SNL/CA Project Team to discuss and resolve design issues may be required. These meetings are a normal part of the design process. For specific design-review requirements, see the project-specific Design Criteria.

In addition to the design requirements described in this manual, instructive information is provided to explain the sustainable building practice goals for design, construction, operation, and maintenance of SNL/CA facilities. Please notify SNL/CA personnel of design best practices not included in this manual, so they can be incorporated in future updates.

You must convey all documents describing work to the SNL/CA Project Manager in both hard copy and in an electronic format compatible with the SNL/CA-prescribed CADD and other software packages, and in accordance with a SNL/CA approved standard format. Print all hard copy versions of submitted documents (excluding drawings and renderings) double-sided when practical.

1.2 Audience

SNL/CA Facilities Management has written this Design Standards Manual for design professionals who perform work for SNL/CA. The contents of this manual represent institutional knowledge derived from SNL/CA Facilities Management design, construction management, operations, and maintenance. To be more efficient and effective in managing SNL/CA's extensive construction and drawing files, refer to this manual first for design work. The manual is directed to you as a competent design professional and is not intended to be a detailed design handbook.

The manual contains general requirements that apply to non-nuclear and non-explosive facilities. For design and construction requirements for modifications to nuclear or explosive facilities, see the project-specific design requirements noted in the Project Design Criteria.

The criteria and standards presented in the manual are those determined to be the minimum acceptable values necessary to result in system designs having satisfactory functional characteristics, durability, and operational suitability. You must strive for the best design to suit the circumstances involved, and the designs must reflect sound professional judgment at all times. In addition, you must coordinate design efforts with other project discipline design team members for an integrated site design approach.

1.3 Engineered Safety

1.3.1 Safety-by-Design Intent

Safety is an attribute of a system of interconnected elements, including people, procedures, facilities, equipment, and the hazards inherent in them to which they are applied. Accident pathways resulting from human error must be identified upfront and removed or blocked by design intent. Safety is most effectively and efficiently achieved by designing it into the system at the conceptual or initial planning stages. However, it should not be reflexively assumed that designing safety features into an existing system will be difficult, time-consuming, or expensive. Effort expended toward this aim should be proportional (graded) to the severity of potential accident consequences.

1.3.2 Understand Technical Basis

The A/E professional needs to fully work with SNL/CA Facilities Management Department and the Sandia line customer, if applicable, to determine the scope and basis for any design, which, at a minimum, should be in accordance with the standards listed as references in Section 1.4 below. Furthermore, the maintainability of the system(s) needs to be included in the design, which should eliminate hazards to maintenance personnel where attainable (i.e., placing equipment at a level that does not require ladders for routine maintenance).

1.3.3 Identify and Control Hazardous Energy Sources

Design hazardous energy systems to the standards listed in Section 1.4 or to the standards listed in Chapters 2–11 of this manual, whichever is more stringent, for all pressure and energy systems.

1.3.4 Unacceptable Consequences

Unacceptable consequences at Sandia include any of the following:

- Accidents that result in a serious occupational injury per ESH100.4.RPT.3, *Report Occurrences*
- Significant violation of environmental regulations
- Unplanned facility outages or interruptions that significantly impact critical mission work

These unacceptable consequences will be considered during the design process.

1.3.5 Risk Assessment

The designer shall first give due consideration to controls that would prevent an accident from happening rather than mitigating accident consequences. Section 1.4 references the design codes and standards that incorporate inherent failure-mode analyses for those systems that are designed to eliminate or mitigate hazards. In the event the design has unique hazards not addressed by any code or standard, the designer shall assess these hazards utilizing appropriate failure-mode analysis methodologies.

1.3.6 Positive Verification

Consistent with the concept that safety is an attribute of a system, the mindset should be to keep the elements connected not only during the design phase, but during the execution phase as well. To facilitate this process the following steps should be taken during the design process:

- If required in the Project Design Criteria, the A/E professional will provide designs to the Sandia Operations Team for design review at specified design phases.
- Once designs have been approved, any changes to the design must be approved by the A/E Engineer of record and the Sandia Operations Engineer.

For large projects, as determined by the Sandia Operations Team, a third party commissioning agent will be brought into the project from the design phase to review the designs for single point failures in critical systems and to fully commission the project from design to turnover to Sandia National Laboratories.

1.4 References

Unless otherwise noted, comply with the latest editions of the following references. The latest versions of construction specifications and standard drawings can be provided by the SNL/CA Project Lead.

1.4.1 Department of Energy Directives

Follow these Department of Energy (DOE) guides, manuals, orders, and standards:

- DOE Guide 430.1-1X, *Cost Estimating Guide for Program and Project Management*
- DOE Manual 473.1-1, *Physical Protection Program Manual*
- DOE Order 413.3, *Program and Project Management for the Acquisition of Capital Assets*
- DOE Order 414.1A, *Quality Assurance*
- DOE Order 420.1B, *Facility Safety and the Contractor Requirements Document*
- DOE Order 436.1, *Departmental Sustainability*
- DOE G413.3-6A,High Performance Sustainable Building
- DOE Standard 1020-2012, *Natural Phenomena Hazards Design Criteria for Department of Energy Facilities*

- DOE Standard 1021-93, Chg 1, *Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components*
- DOE Standard 1090-2011, *Hoisting and Rigging*

1.4.2 Code of Federal Regulations

Follow these titles, chapters, and lower-level designations in the Code of Federal Regulations (CFRs):

- 10 CFR 436, Subpart A, *Methodology and Procedures for Life Cycle Cost Analysis*
- 10 CFR 830, *Nuclear Safety Management*
- 10 CFR 835 Subpart K, *Occupational Radiation Protection Design and Control*
- 10 CFR 851, *Worker Safety and Health Program*
- 29 CFR 1910, *Occupational Safety and Health Standards*
- 29 CFR 1926, *Safety and Health Regulations for Construction*

1.4.3 Commercial Codes and Standards

Sandia National Laboratories has adopted international and national commercial codes and standards from the following organizations and others:

- American National Standards Institute (ANSI)
- American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE)
- Crane Manufacturers Association of America (CMAA®), Inc.
- National Fire Protection Association (NFPA®)
- National Roofing Contractors Association (NRCA)
- Illuminating Engineering Society of North America (IESNA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)

Please follow these codes, guidelines, manuals, and standards:

1.4.3.1 Codes

- California Code of Regulations, Title 24, also known as the California Building Standards Code
- 2013 California Administrative Code, Title 24 Part 1
- 2013 California Building Code, Title 24 Part 2 (Parts 8 & 10 included)
- 2013 California Electrical Code, Title 24 Part 3
- 2013 California Mechanical Code, Title 24 Part 4
- 2013 California Plumbing Code, Title 24 Part 5
- 2013 California Energy Code, Title 24 Part 6
- 2013 California Fire Code, Title 24 Part 9
- 2013 California Green Building Standards Code, Title 24 Part 11 (CalGreen Code)
- 2013 California Referenced Standards Code, Title 24 Part 12

- NFPA 70, National Electric Code,
- NFPA 72, *National Fire Alarm and Signaling Code*
- NFPA 101, *Life Safety Code*®
- IEEE C2-2007, *National Electrical Safety Code*®

1.4.3.2 Guidelines

- General Services Administration (GSA) Architectural Barriers Act Accessibility (ABA) Standard for Federal Facilities. http://www.access-board.gov/ada-aba/aba-standards-gsa.cfm#a402. Handbooks, Manuals, and Other Documents
- Federal Highway Administration, *Manual on Uniform Traffic Control Devices*
- IESNA *Lighting Handbook*, 10th edition
- *NRCA Handbook of Accepted Roofing Knowledge*
- *NRCA Roofing Manual*

1.4.3.3 Databases and Research Projects

- ASHRAE Research Project 308-1985, *Investigation of Duct Leakage*
- *ASHRAE Duct Fitting Database CD*, Version 6.00.00 (2011)

1.4.3.4 Standards

- ANSI/ASHRAE Standard 90.1-2013, *Energy Standard for Buildings Except Low-Rise Residential Buildings*
- ANSI/ASHRAE Standard 100-2006, *Energy Conservation in Existing Buildings*
- ASHRAE Standard 62.1-2007, *Ventilation for Acceptable Indoor Air Quality*
- CMAA Specification No. 70, *Multiple Girder Cranes* (2010), "Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes"
- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- NFPA 70E, *Standard for Electrical Safety in the Workplace*® (600V and below)
- NFPA 75, *Standard for the Protection of Information Technology Equipment*
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*
- NFPA 90B, *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*
- NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities*
- NFPA 780, *Standard for the Installation of Lightning Protection Systems*
- NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*
- IEEE 315-1975, *Graphic Symbols for Electrical and Electronics Diagrams*
- IEEE 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*
- *IEEE 3000 Series Collection for Industrial & Commercial Power Systems*
- SMACNA, *HVAC Duct Construction Standards – Metal and Flexible* (2005)

1.4.4 Specifications, Drawings, and Standards

Follow these construction specifications, drawings, guidelines, manuals, and procedures, which SNL/CA Facilities Management maintains:

- SNL Standard Construction Specifications
- SNL Standard Drawings
- *CADD Standards Manual*
- *Site Master Plan*
- *Landscape Master Plan*
- *Sandia National Laboratories Telecommunications Systems Design Manual*

1.5 Updates to This Manual

As the industry standards and practices cited in this manual change, SNL/CA Facilities Management will issue updates. SNL/CA Facilities Management intends to revise the manual when changes are warranted. Consult the Project Manager for the current version.

2.0 General Design Standards and Procedures

2.1 Introduction

As a design professional, or the Architect/Engineer (A/E) doing work for Sandia National Laboratories, California (SNL/CA) the A/E is responsible for the final design of a project, according to the requirements in this *Design Standards Manual*, project-specific design criteria (when included), and additional contract documents. It is also the A/E's responsibility to provide a facility design that meets the required functions in the most cost-effective manner to satisfy current mission needs of SNL/CA and provide flexibility, as requested, in meeting future mission needs.

The A/E is responsible for compliance with State of California requirements for licensure as regulated by the California Architects Board and the California Board for Professional Engineers, Land Surveyors, and Geologists.

In accordance with the laws of the State of California, the A/E's design must comply with the 2013 California Administrative Code, Title 24, Part 1, and the various Parts of the 2013 California Building and other Codes and Standards referred to in Chapter 1.0, Introduction. The deliverable design package, including drawings, specifications, code footprint/analyses, and calculations must bear the seal, signature, and date of signature from the California licensed design professional responsible and in charge of design. Multidiscipline projects require multiple seals, signatures, and dates of signatures. Alterations to the design package (including the post-construction red-lines) that materially change the original design intent, and result in the production of new or changed documents, must be resealed. Amended construction documents must be maintained in accordance with the California Building Code.

The A/E is also responsible for following SNL/CA standard specifications and standard drawings and verifying that the drawings match these standards.

2.2 Design Process

The SNL/CA site uses an integrated whole building design approach on all new construction and major renovation projects. This design approach considers the interrelationships among building siting, design elements, energy and resource constraints, building systems, and building function, before predesign activities are initiated. To identify the effects these factors have on one another may require a multidisciplinary design and construction team consisting of Site Planners, Landscape Architects, Architects, Engineers, Contractors, Interior Designers, Lighting Designers, Building Owners, Occupants, Maintenance Personnel, and any other relevant stakeholders.

The A/E is responsible for determining all requirements necessary to create a comprehensive, functional, buildable, and code-compliant project design. Use resources, such as the Conceptual Design Report (CDR), design criteria, this *Design Standards Manual*, and additional information gathered through the Title I "programming" exercise to determine solutions to design questions. During the initial phase of a project, the CDR and design criteria are developed from an analysis of project requirements to establish functional and performance specifications and architectural design attributes. The development of the CDR and design criteria must align with the standards and methods of this *Design Standards Manual*. To ensure this alignment, initial design phase activities must also include the participation of the SNL/CA project team, as well as the facility owner, occupant, and maintenance representatives.

A working relationship is developed early in the design process between the A/E team and the SNL/CA project team to expedite the transfer of additional required information. The A/E may be required to go directly to additional SNL/CA stakeholders to obtain additional design direction if the SNL/CA Project Lead does not have that information. All correspondence and stakeholder interactions of this type must be documented and copied to the applicable SNL/CA project team members. The SNL/CA Project Lead must provide an expanded list of all project stakeholders to the A/E early in the design process.

2.3 Design Quality

Architectural and engineering design must be code-compliant, functional, and cost-effective. The A/E tailor the facility's design to fit its intended function using sustainable design principles, including but not limited to low maintenance, energy and water efficiency, material and resource conservation, and indoor environmental quality. The A/E shall design facilities that are easily maintained, with readily accessible equipment areas, low maintenance interior and exterior surfaces, and quality roofing systems. To promote an orderly and efficient appearance, architectural features of new facilities should complement and enhance existing architecture at the site.

Begin with informed assumptions and proceed to identify solutions. As problems gain more definition and as alternative solutions become more refined, the A/E shall use professional judgment and ingenuity to produce a coordinated interdisciplinary design that is cost-effective, easily contractible, constructible, high-performing in energy efficiency, code-compliant, and aesthetically pleasing. Along with support consultants, the A/E is responsible to perform functional analyses and programming in developing design solutions. These solutions reflect coordination of the competing functional, budgetary, and physical requirements for the project. Prior to and throughout the design process, meetings to establish, discuss, and resolve design issues are required. These meetings are a normal part of the design process and are critical to achieving a fully integrated, whole-building design. For specific design review requirements, see the project-specific design criteria.

Throughout the design process, conduct discipline coordination sessions to resolve conflicts about the use of building space. In the concept-definition phase and up to 30% design completion, mechanical rooms, electrical rooms, utility chases both intra-floor and inter-floor, and outdoor equipment, such as substations and cooling towers, are shown on the drawings. As equipment items are chosen up to 60% design completion, the drawings are refined to include feeder conduit and liquid piping runs, major ductwork runs, equipment locations on the utility room floor plans and outside, and general assignment of interstitial spaces above ceilings and in chases. At 90% design completion and with delivery of the final contractual design package, all discipline conflicts must be resolved, to include but not be limited to, the following:

- Compliance of all design documents with applicable building codes
- National Electrical Code® (NEC®) clearances and exit paths for electrical panel boards, switchgear, and drives
- Access to air handlers and other HVAC equipment, including space to service filters, fan belts, motors, and bearings, and remove heat exchanger components
- Clear space to open all access doors and panels fully, with the understanding that doors of one equipment item may swing into the clearance space of another when the second item does not require simultaneous access
- Design of service lights, catwalks, and convenience receptacles in larger interstitial spaces where the room lighting and receptacles may be inadequate
- Three-dimensional space assignment of the disciplines in interstitial spaces and chases

- Structure-mounted pick points and dolly space for removal and replacement of major items, such as a large motor
- Location of lighting fixtures so they are not blocked by other equipment and that they cast light into spaces that can be occupied and not, for instance, on top of a fume hood. This includes arrangement of fixtures in a lay-in ceiling to accommodate modular furniture and not just in a symmetrical pattern for an empty room.
- Location of variable air volume (VAV) boxes such that they can be serviced easily
- Location of electrical junction boxes for lighting, communications, alarms and access control, and other systems that could reasonably be expected to require periodic access during the life of the building, such that access to each item does not require dismantlement or outages of items not related to that discipline
- Minimizing the location of major items within a closed area (formerly referred to as a vault-type room or VTR), such that they are not readily accessible for servicing, even when dedicated to that closed area
- Location of outside equipment such that adjacent space use is compatible; for instance, not locating an air intake near a vehicle area, and not locating fire sprinkler and roof drains near pedestrian paths
- Partitioning of building utility space separate from (but may be adjacent to) programmatic utility runs
- Full design (route and spacing) of conduit and piping runs of 2 inches and larger, and restricted use of home-run designators to smaller terminal runs and branch circuits
- Access means or choice of equipment items that afford ready servicing in lobbies, open stairwells, and other areas where ceiling height is multistory

Not all projects require a formal 30, 60, 90 percent design review. Refer to the project specific Design Criteria for specifics.

Portions of a facility design that are subcontracted, such as site preparation, asbestos remediation, fire protection sprinkler design, and similar specialties, must be contracted for and delivered such that the contracted portion is incorporated into the deliverable package, so it may be considered by the Engineer or Architect with responsible charge, reviewed by the SNL/CA project team, and integrated so that the subcontracted effort is a part of the whole as if it had not been subcontracted For example, the A/E must not set aside portions of the design work to be completed later and forward as a short-suspense submittal or shop drawing.

2.3.1 Value Engineering

If required per the project specific Design Criteria, the A/E is responsible for performing value engineering to determine the project component alternatives that satisfy the same basic function or set of functions at the optimum project cost. Value engineering, which always includes, at a minimum, the SNL/CA project team, project owner, and occupants, follows a result-driven job plan consisting of the following phases:

- Selection
- Information
- Creativity
- Analysis

- Development
- Presentation
- Implementation
- Verification

Value engineering begins during the programming stage of the design and continues throughout the design process.

2.3.2 Life-Cycle Analysis

This section applies only to those projects where Life-Cycle Analysis is required per DOE directives or the project-specific Design Criteria, The Federal Energy Management Program (FEMP) established 10 CFR 436 to promote life cycle cost-effective investments in energy systems, water systems, and energy and water conservation measures for federal buildings. This life-cycle cost (LCC) methodology is a systematic analysis of relevant costs, excluding sunk costs, over a study period, relating initial costs to future costs by discounting future costs to current values.

Perform LCC analyses in the early phases of line-item projects and major projects to support value engineering and sustainable design. Life-cycle costing makes economic comparisons between systems similar in function and enables selection of the lowest LCC system.

Combining value engineering and life-cycle costing can potentially identify the best value alternative by comparing the first cost and life-cycle costs of each alternative. In this manner value engineering and life-cycle costing are both used during early project phases to develop an "equal playing field" for determining tradeoffs and making decisions to balance, among other criteria, environmental performance with total cost, reliability, safety, and functionality. This equal comparison enables sustainable development technologies and integration to be fully evaluated for overall performance.

An integrated project team approach is critical to achieving an integrated whole building design. Value engineering and LCC professionals should be included in the design team in the earliest-possible project phases. The framework for integrating value engineering and LCC into the design process is as follows:

- Perform a requirements assessment to establish the parameters for sustainable development
- Perform conceptual planning using macro-level value engineering and life-cycle costing (including energy modeling)
- Conduct programming and budgeting activities
- Perform design using complete value engineering and life-cycle costing evaluations

2.4 General Requirements for Construction Drawing Files

2.4.1 CADD Standards Manual

Facilities drawing files for SNL/CA must be created or modified to comply with the *CADD Standards Manual*. This manual contains specific information and files related to CADD requirements, standards, and processes. Exceptions to compliance requirements may be made as necessary to benefit the project, if approved by the SNL/CA Sandia-Delegated Representative (SDR), who is usually the SNL/CA Project Lead. No exceptions are allowed for final as-built files.

2.4.2 Locating Drawing Files

Because facilities at SNL/CA are continually being modified or extended, Facilities Engineering uses an active record drawing file system to represent those changes. Identification of the most up-to-date record drawing files that are affected by a particular project is part of the project design requirements. Half-scale hard copies and current, online, read-only access to numerous drawing files are available in the Facilities Engineering Library.

2.4.3 Requesting Drawing Files from the Drawing File System

SNL/CA Facilities Management operates a closed drawing file system. Only authorized personnel with a valid user name and password may check out record drawing files. Off-site contractors are assigned an on-site CADD Technician as a point-of-contact for all files being checked in and out of the Facilities Document Management System.

2.4.4 Using Record Drawing Files

Modifications to existing facilities must be made by revising the record drawing files, unless otherwise directed. New drawings must be prepared if the existing record drawings are too crowded or obsolete. All plans, elevations, sections, details, and diagrams must be completed to sufficient size and detail to clearly and completely define the project for bidding and construction purposes.

Because the hard-copy drawings may be outdated, information used to interface or develop the design must be field verified.

2.4.5 Drawing Numbering System

Distinguishable types of project drawing plot files that are commonly (or are specified to be) created on separate drawing files must be numbered in a modified "Uniform Drawing System" numbering scheme as described in the *CADD Standards Manual*.

2.4.6 Standard Drawings

Standard drawings are used to facilitate the design process by providing typical details and templates for incorporation into design packages. Hard copies of building master drawings are located in the SNL/CA Facilities Management Library These drawings are not to be removed from the Library, though copies of the drawings may be made. All master drawings are CADD vector files and are also available in Adobe Acrobat (.pdf) format. If electronic copies are required but not available in the A/E's system, request them from the SNL/CA Project Lead.

2.4.7 Drawing Set Organization

The construction drawing set must be organized as shown in Table 2-1.

Table 2-1 Drawing Set Organization

Discipline	Discipline Designator
G	General
C	Civil
W	Civil Work
L	Landscape
S	Structural
A	Architectural
F	Fire Protection
P	Plumbing
M	Mechanical (includes HVAC controls)
E	Electrical
T	Telecommunications
T	Security
	Other disciplines (such as non-HVAC controls and asbestos)

2.5 Construction Specifications

2.5.1 Overview

The SNL/CA Construction Specifications include Standard Specifications, Special Specs, and MasterSpec templates. The Standard Specifications contain broad specifications that are typically used in their entirety without modification. Project specific specifications are referred to as Special Specifications. The Master Specification templates are available to be edited to reflect project-specific applications.

2.5.2 Standard Specifications

Standard Specifications have been developed by SNL/CA Architects and Engineers to establish a consistent building system throughout the SNL/CA campus with a certain level of quality, energy efficiency, safety, security, and maintainability. The A/E must become familiar with the specifications verify that they are applicable to their project or if modifications are required. If it is determined that a Standard Specification needs modifications for a specific project, the A/E must consult with the SNL/CA project team to discuss the extent of the changes.

Continuous improvement is a goal of the SNL/CA Facilities Management and the design community is encouraged to submit ideas for improvement.

2.5.3 Project-Specific Specifications

Project specific specifications are specifications developed for a particular project and only apply to that project. Project specific specifications are either a new specification or a modified Standard Specification. These specifications must be written in accordance with the *Construction Specifications Practice Guide* published by the Construction Specifications Institute (CSI).

Project specific specifications may be considered as Standard Specification if submitted to the SNL/CA Facilities Management as an improvement idea.

2.5.4 MasterSpec Templates

Master Specification Templates from MasterSpec® (contact the SNL/CA Project Lead for the latest required format) are available from the Standards Program that may be used to develop a new specification to be considered as a standard or as project-specific.

2.6 Miscellaneous Design Issues

2.6.1 Sandia-Furnished Material

The A/E shall identify all Sandia-Furnished Material (SFM) in the specifications and the construction contract and verify that the existing equipment is functional for the intended use in the design.

2.6.2 Installation of Customer Equipment

When installing equipment owned by the end-user customer, The A/E must document all installation issues with the equipment, including size, weight, electrical, data communications, chilled water, exhaust, drains, serviceability, safety, and so on.

2.6.3 Descriptive Submittals

Projects submittals must be in accordance with SNL/CA Standard Specification 01330, *Submittal Procedures*. Design professional must review all specifications to verify that the desired Descriptive Submittals are being requested and must list all necessary submittal requirements to ensure full project compliance.

2.6.4 Master Equipment List Update

When equipment items are removed or added to a building as part of a project, the design professional must provide information to SNL/CA's Maintenance Planning Services to update their database as appropriate. This is especially important and applicable for equipment replacements, and remodels and renovations involving equipment replacements, as well as new construction projects. Advise the SNL/CA Project Lead (PL) or project team discipline lead, as applicable, of the scope of the project during design and provide the list of as-designed equipment to be provided/removed. The list becomes a part of the design package and is updated during construction, as necessary, by approved submittals or change orders.

2.6.5 Temporary Services

Prepare complete designs for all temporary service connections and installations required for the construction contractor's use of government-owned utilities. These designs are subject to requirements noted herein.

2.6.6 Site Access Requirements

Most areas at SNL/CA are subject to security and access regulations. To obtain access to the Project areas, the A/E must submit a letter to the SDR identifying personnel needing access, company name or affiliation, and the anticipated dates and times of visits. Those who have an active U.S. Department of Energy (DOE) L or Q clearance are furnished temporary badges that permit access. All others are provided an escort while in a secure area. All personnel must have a badge that is visible and worn above the waist, regardless of whether they are in secure areas or not. Contact the SDR at the beginning of the project for more details.

2.6.7 Tobacco-Free Campus Requirement

Sandia National Laboratories sites are completely tobacco-free campuses per corporate procedure HR100.4.10, *Maintain a Tobacco-Free Environment*; therefore, all facility designs must not include any provisions for smoking areas, smokeless tobacco use, tobacco vending, or similar features.

2.7 Design Information and Calculations

Design drawings for all disciplines must be accompanied by sufficient supporting calculations and system operating conditions to clearly convey assumptions, constraints, and how code requirements have been met. Additionally, design of chemical rooms, service/storage areas/yards, and/or other elements - including hazardous materials and life safety implications - must include relevant reference to codes-driven tables and calculations (and calculation sheets). Information and calculations must be provided with each submittal.

The A/E must present design information and calculations on 8½-inch by 11-inch sheets with minimum half-inch margins on all sides, logically arranged, indexed, and bound in book form. Type or hand-letter all material, neatly arrange the sheets, and include the sources of all contents. Present the formulas used and clearly state all assumptions made. Present the following information on each sheet:

- SNL/CA Project Number
- Sheet Number
- Subject
- Building Number
- Date

Include the following as supporting information:

- System and subsystem flow diagrams, including operating conditions and parameters
- Free-body diagrams
- One-line schematic diagrams, including operating conditions and parameters

- Utility system calculations, including operating conditions and parameters
- SNL/CA-provided information and direction

When using computer-aided design systems to perform design calculations, also include:

- The computer program name and version used.
- Information on the building model or paradigm used by the software, so that an engineer unfamiliar with the program can understand the functions, limitations, and method of analysis used. The documentation must be sufficiently complete to allow an engineer to verify the method of data input and interpret the output calculation by hand. This requirement can be waived if the software is also in use at SNL/CA.
- Identification of the free-body diagrams, one-line power diagrams, marked plans, flow diagrams, and sketches that are part of the design package, so that another Engineer can easily check for accuracy. This can be part of the calculations pages mentioned above.
- A copy of the computer output. Retain a complete copy of input data, worksheets, discs, and other quality assurance records with the project file for possible audit purposes.
- Spot-reviews or verifications of the computer output for accuracy and reasonableness.

If the building is a Moderate Hazard Facility, a separate Design Basis Document must be provided, describing all elements and systems of the building.

2.8 Energy Conservation and Sustainable Design Requirements

The goal of SNL/CA is to create buildings and infrastructure that promote a healthful, resource-efficient, and productive working environment. To achieve this goal, all new buildings and renovation projects must be designed, constructed, and commissioned for operation using an integrated whole-building design approach and the latest sustainable building technologies. Every reasonable effort must be made to employ life-cycle cost-effective energy and water conservation concepts during design and construction based on the established value engineering concepts that ensure an appropriate balance between project cost, security, maintainability and facilities life-cycle costs.

Sandia National Laboratories is included in the list of federal agencies required by the Energy Policy Act of 2005 (Public Law 109-58) to incorporate the performance criteria used for ENERGY STAR®-qualified and FEMP-designated products into procurement contracts for energy consuming products and systems. These requirements must be included in all construction specifications and construction, renovation and service contracts.

To demonstrate a commitment to this goal, the following strategies, as confirmed by the responsible SNL/CA Project Lead, must be pursued for all project work at SNL/CA:

- Assess opportunities from a whole-building approach to maximize energy and water conservation through comprehensive, integrated evaluations of all components, systems, and, as appropriate, processes.
- Use life-cycle cost decision-making balanced with first cost constraints.
- Commission equipment and controls in all new construction and renovation projects as an integrated effort during construction, to verify building system performance and functionality for the customers and for Facilities operations and maintenance.

- Employ a broad range of advanced energy and water efficiency strategies, including but not limited to central plant optimization, airside supply and exhaust distribution optimization, energy recovery methods, lighting design optimization, and water use reduction measures.
- Specify environmentally preferable construction materials and construction waste reduction methods.
- Seek recognized certifications that demonstrate this philosophy, such as Leadership in Energy and Environmental Design (LEED®), ENERGY STAR, and Green Building awards and certificates.

2.8.1 Sustainable Design, Guiding Principles, and LEED Certification

Sustainable or green-building design minimizes site disturbance, optimizes energy and water use, provides good indoor environmental quality, selects environmentally preferable building products, handles construction and demolition waste in a resource-conserving manner, and improves operations and maintenance.

Two references are commonly recognized as the standard for Sustainable Design and Development of Buildings and Infrastructure. The U.S. Green Building Council (USGBC®) has developed the Leadership in Energy and Environmental Design (LEED) Green Building Rating System to evaluate life cycle environmental performance from a whole-building perspective. In addition, an interagency federal task force has developed a set of sustainable design and development principles, comparable to the LEED rating system, known as the Whole Building Design Guide. Both of these programs provide excellent information and should be referenced while conducting facility planning and design work for SNL/CA. Search the Internet for more information about these programs. Lastly, the CalGreen Code, provides very specific requirements to be implemented as Nonresidential Mandatory Measures for projects. The combination of these three standards and codes are to be applied to Sandia/CA projects.

The A/E must use sustainable design principles for work conducted at SNL/CA. A/E firms that market sustainable, energy-efficient design as part of their services must assist the SNL/CA Facilities Management in institutionalizing sustainable design efforts at SNL/CA.

All new buildings and major renovation projects must meet the High-Performance Sustainable Buildings Guidance which includes the *Guiding Principles for Sustainable New Construction and Major Renovations* (*Guiding Principles*) LEED certification requirements, plus the mandatory requirements of the CalGreen Code . These are separate, but related, activities.

Submit a Sustainable Design Report during the design process that outlines the sustainable-design approach and demonstrates compliance with the both *Guiding Principles* and LEED certification requirements.

A *Guiding Principles* Subject Matter Expert (SME) is available at SNL/CA to assist the SNL/CA Project Lead in documenting compliance. *Guiding Principles* compliance is internally verified and tracked using the EPA web-based Portfolio Manager system.

In addition, all new buildings and major renovation projects must be certified as "green" buildings through the LEED rating system at the Gold level or higher. All new building and major renovation designs , must be scored using the LEED rating system, in anticipation of submission for certification as a green building. Actual LEED certification requires applicant buildings to satisfy a number of prerequisites and attain a certain number of credits. Once the LEED program prerequisites have been satisfied, applicant buildings are rated based on the number of credits achieved within the rating system. There are four levels of LEED certification: Certified Silver, Gold, and Platinum (highest).

The SNL/CA Project Lead will determine who in the Sandia National Laboratories organization responsible to register and obtain certification. For example, SNL/NM provides a LEED Accredited Professional® (AP®) to register and obtain such certification. The certification process first requires registration of the building project with the USGBC to show intent to obtain LEED certification. The USGBC recommends registering early in the project, preferably during the schematic design phase. Following completion of construction activities, an application is submitted to the USGBC LEED Certification Manager. This application includes a narrative of the project, a LEED Scorecard, complete documentation per credit (tabbed) with cover sheets from the Application Template, and a certification fee. The application then goes through an administrative review, a technical review, followed by notification of LEED certification. The USGBC presents the project with a certificate and a metal LEED plaque indicating the certification level. The standard review timeline can take anywhere from eight weeks to several months. As a member of the USGBC in the government-owned, contractor-operated category, SNL/CA building projects are entitled to receive membership benefits and discounts on fee schedules relating to the registration, technical support, and certification process.

See Table 2-2 for additional requirements based on project type and size.

Table 2-2 High-Performance Sustainable Building Requirements Matrix

Building Type	Description	Size (Gross Square Feet)	Project Cost	*Guiding Principles* (GP) Required? New Construction, Major Renovation, or Existing Building	CalGreen Code	USGBC LEED Required? and Minimum Certification Level	Comments
New	New Construction	>5,000	>$5M	Yes	Yes	LEED New Construction—Gold	Parking structures, process and power-generating systems, and distribution systems are exempt.
		Any size	<$5M	Yes	Yes	No	
	Lease—New Construction (NC)	>5,000	N/A	Yes	Yes	LEED NC—Silver (Gold preferred)	
	Grandfathered	Any size	N/A	No		LEED NC—Any level	Must meet 12/1/08 requirement
Existing	Existing Building—as is	>5,000	N/A	Yes	No	No	15% must meet GP by FY15 using FY09 baseline (building count or GSF still under discussion). Leases >5,000 GSF included.
	Major Renovation	>5,000	>$5M	Yes	Yes	LEED Existing Buildings: Operations & Maintenance™—Gold	
		>5,000	<$5M	Yes	Yes	No	
		<5,000	<$5M	No	Yes	No	
	New lease	>5,000	N/A	Preferred	No	LEED Existing Buildings: O&M—Silver preferred	Preference given to LEED buildings, if available and cost-effective. LEED Commercial Interiors (CI) might apply, if leasing space in an office building.
	Existing Lease (option renewal)	>5,000	N/A	No	No	No	Leases >5,000 GSF included in existing building FY09 baseline and eligible for the 15%.
	Grandfathered	Any size	Any cost	No	No	LEED Existing Buildings **or** Existing Buildings: O&M—Any level	Must meet 12/1/08 requirement

2.8.2 Building Systems Commissioning

The SNL/CA and the CalGreen Code requires that all new construction and major renovation projects include building systems commissioning as a quality control measure. At a minimum, commissioning procedures verify and ensure that fundamental building elements and systems are operational and are designed, installed and calibrated to operate as intended. The following fundamental best-practice commissioning procedures must be followed:

- Designate a commissioning authority, preferably during preliminary design
- Document the operating parameters for each element and system included in the scope of commissioning
- Create a commissioning plan that
  - Integrates commissioning requirements into the contract documents
  - Verifies adequacy of installation, functional performance, training, and manufacturer's documentation
  - Documents the results upon completion of commissioning, with an action plan as necessary to ensure correction of any out-of-compliance condition

The SNL/CA Project Lead designates the commissioning team or commissioning authority for the project and ensures that appropriate budget for commissioning has been established..

2.8.3 Energy Service Meters

Each distinct building energy service must have a measurement system to accumulate a record or indicator reading of the overall amounts of the electricity and natural gas being delivered. Exception: A building of 5,000 gross square feet (GSF) or less in a complex of buildings may have its measurement system included with another building in the same complex. All required meters must be equipped with provisions to allow for remote reading throughout the SNL/CA Energy Metering System.

2.8.4 Water Conservation Measures

SNL/CA requires that all new construction, major renovation and outdoor landscaping projects include water efficiency and conservation measures as required by the CalGreen Code. Project requirements to be considered and integrated into design include:

- Determination of separate metering devices for indoor water use.
- Integrating water reduction and conserving plumbing fixtures
- Integration of conservation measures for outdoor potable water use and irrigation design.

The A/E shall provide a summary of design bases and Water Conservation Measures to be incorporated into the design to the SNL/CA Project Lead for consideration and approval.

2.8.5 Material Conservation and Resource Efficiency

SNL/CA requires that all new construction and major renovation projects include material conservation and resource efficiency measures as required by the CalGreen Code. Project requirements to be considered and integrated into design include:

- Water Resistance and Moisture Management.
- Construction Waste Reduction, Disposal and Recycling
- Building Maintenance and Operations Recycling

The A/E shall provide a summary of design bases for Material Conservation and Resource Efficiency requirements to be incorporated into the design to the SNL/CA Project Lead for consideration and approval.

2.8.6 Environmental Quality

SNL/CA requires that all new construction and major renovation projects include environmental quality measures as required by the CalGreen Code. Project requirements to be considered and integrated into design include:

- Pollutant Control
- Indoor Moisture Control
- Indoor Air Quality
- Environmental Comfort
- Outdoor Air Quality

The A/E shall provide a description of Environmental Quality design elements to be incorporated into the design to the SNL/CA Project Lead for consideration and approval.

2.8.7 Energy Monitoring and Control Systems

All new permanent buildings greater than 5,000 square feet must have a Facilities Control System for interconnection with the SNL/CA Facilities Control System (FCS), unless specifically exempted by the project-specific design criteria, the SNL/CA Project Lead, or both.

2.8.8 Energy Policy Act of 2005 Requirements

As required by the Energy Policy Act (EPAct) of 2005, new buildings must be designed to achieve energy-consumption levels approximately 30% below those of the 2004 ASHRAE standard on the International Energy Conservation Code, unless clearly demonstrated not to be LCC-effective. Similar reductions are required for major renovations of existing buildings. The exact energy-consumption goals for a particular building must be negotiated during the Title I and Conceptual Design activities, taking into account the building's mission, model, and programmatic equipment.

2.9 Conceptual Design (Project Definition) Requirements

If included in the A/E contract, provide conceptual design (project definition) scope and deliverables including the following:

- Updated functional and operational requirements documents
- Space and equipment data sheets
- Energy Conservation and Sustainable Design Requirements Plan
- Updated record drawings for Request for Quotation (RFQ) purposes

- Site plans
- Floor plans
- Building elevations
- Building sections

2.10 Title I (Schematic Design) Requirements

Provide Title I Quality Assurance Review deliverables (unless stated otherwise by design criteria) to include the following:

- Design analysis (design narrative and calculations)
- Drawing prints and files
- Preliminary cost estimates
- All additional requirements as defined in the project-specific design criteria

These Title I review requirements are described in the following sections.

2.10.1 Design Analysis

Present conceptual design analyses for the entire facility or portions thereof, including appropriate environmental or utility systems when required. The conceptual design analyses for alternate approaches to the job include the following:

- Statement of purpose and function
- Statement of factors considered and provided for
- Economic justification
- References of previous studies of record

In general, these analyses present the complete documentation of the facts that are considered when forming conclusions for alternate approaches.

After the analyses have been considered and a choice agreed on in conference with the SDR, complete the chosen conceptual analysis and submit it at Title I. At a minimum, it must contain the pertinent facts involved in the concept, the conclusions reached, along with the reasons for these conclusions, and the alternatives considered.

2.10.2 Drawings

The design criteria identify the specific requirements for determining percentage complete for each discipline prior to starting design. If not indicated, the Title I final submittal is approximately 30% complete for the entire project. The deliverables required under this phase are described in Table 2-8, Project Deliverables.

2.10.3 Preliminary Cost Estimates

Preliminary Construction Cost Estimates are submitted along with the Title I package. Estimates must be prepared per requirements noted in DOE Order 430.1-1, *Cost Estimating*. Additional direction may be provided in the design criteria. Appropriate labor rates for use in the estimate must be confirmed with the project team, and procurement analysis (make or buy, design build) must be adequately addressed by the project team for use in the estimate.

2.11 Title II (Design Development – 60% Completion) Requirements

Provide Title II Quality Assurance Review deliverables (60% complete) to include the following:

- Drawings
- Specifications
- Design Analysis
- Cost Estimate
- Energy Conservation Report (as required by design criteria)

These Title II review requirements are described in the following subsections.

2.11.1 Drawings

Provide complete working-drawing prints and files, prepared in accordance with this manual, and as required under this phase as described in Table 2-8, Project Deliverables.

2.11.2 Specifications

Provide 60% construction specifications prepared in accordance with the procedures in this manual.

2.11.3 Cost Estimate

Submit an Updated Construction Cost Estimate. The estimate must be prepared per the requirements noted in DOE Order 430.1-1, *Cost Estimating*. Additional direction may be provided in the design criteria. The A/E must organize and segregate the estimate so that all exterior work is identified in a separate category. SFE must be included and identified as a separate category.

2.11.4 Energy Conservation Report

Submit an update of the Energy Conservation Report (as required by design criteria) containing the results of energy consumption calculations for the base-case building and the results of the energy analysis and life-cycle cost analysis for any energy conservation alternatives. Deliver complete electronic files (Microsoft Word and Excel) and data files of computer calculations such that SNL/CA could achieve the same results.

2.12 Title II (Design Development – 90% Completion) Requirements

Provide Title II Quality Assurance Review deliverables (90% complete) to include the following:

- Drawings
- Specifications
- Design Analysis
- Cost Estimate
- Energy Conservation Report (as required by design criteria)

These Title II review requirements are described in the following subsections.

2.12.1 Drawings

Provide complete working-drawing prints and files, prepared in accordance with this manual, and as required under this phase as described in Table 2-8, Project Deliverables.

2.12.2 Specifications

Provide 90% construction specifications prepared in accordance with the procedures in this manual.

2.12.3 Cost Estimate

Submit a final Construction Cost Estimate. The estimate must be prepared per the requirements noted in DOE Order 430.1-1, *Cost Estimating*. Additional direction may be provided in the design criteria. The A/E must organize and segregate the estimate so that all exterior work is identified in a separate category. SFE must be included and identified as a separate category.

2.12.4 Energy Conservation Report

Submit the Final Energy Conservation Report (as required by design criteria) containing the results of energy consumption calculations for the base-case building and the results of the energy analysis and life-cycle cost analysis for any energy conservation alternatives. Deliver complete electronic files (Microsoft Word and Excel) and data files of computer calculations such that SNL/CA could achieve the same results.

2.13 Title II (Design Development – 100% Completion) Requirements

Incorporate Sandia NL/CA comments and finalize permit and construction bid documents in their final form as outlined in Chapter 2.12.

2.13.1 Bid Support

Prior to award of construction contract, the A/E must support the SNL/CA project team in the following areas:

- Attendance at the prebid conference
- Response to bidders' requests for information (RFIs)
- Correction of design errors or omissions in the form of prebid addendums
- Possible review of certain elements of the construction proposals prior to Award of Contract

2.14 Title III Requirements - Construction

The A/E must provide Title III services and deliverables (as noted in the contract) to include the following:

- Responses to construction contractor RFIs
- Review and approval of descriptive submittals
- Updated electrical Coordination Study (if required; see 2.12)
- Resolution of constructability change orders
- On-site representation at the construction site
- Attendance at construction progress meetings
- Provide information for Safety Analysis Report
- Site observations

The A/E must create the following as-built documents as part of Title III services (as noted in the contract).

2.14.1 As-Built Drawings

Gather construction as-built notes from the General Contractor and incorporate these notes into the record CAD files.

2.14.2 Calculations

Update the calculations books with any changes required during the course of construction. If the submitted electrical power equipment is different from that which was specified and designed against, perform an updated Coordination Study based on the submitted equipment. If the submitted equipment cannot meet the coordination requirements, reject the submittals.

2.14.3 Correspondence

Deliver all communications and memos that contain pertinent final information to the SDR for record purposes. Organize the sheets in a chronological order of the life of the project.

2.14.4 Descriptive Submittals

Deliver to the SDR all descriptive submittals generated during Title III that were not available during Title II or earlier, such as shop drawings, catalog cuts, Material Safety Data Sheets, and materials information, such as sample boards and maintenance manuals. Organize the descriptive submittals in chronological order by discipline.

2.15 Required Document Quantities for Title I, II, and III

The number of documents to submit to Facilities Engineering for review at Title I and Title II, and for reference at Title III, varies according to project scope and customer organization involvement. In some instances, half-size drawings are acceptable in lieu of full-size drawings. The number and type of drawing sets required are typically specified at the prenegotiation conference or project-specific design criteria.

In all instances where the number of documents was not prenegotiated, the A/E must provide the following at each submittal:

2.15.1 Title I Review

The following deliverables are required for Title I review:

Table 2-3 Title I Review

Deliverable	Quantity
Drawings	1 set D-size, 3 sets 11 inches by 17 inches
Outline Specifications	4 sets
Estimate and Analysis	2 sets
Energy Conservation Report (as specified in the design criteria)	2 sets
All electronic files	1 set disks

2.15.2 Title II Review

The following deliverables are required for Title II review at 60% and 90% completion:

Table 2-4 Title II Review

Deliverable	Quantity
Drawings	1 sets D-size, 3 sets 11 inches by 17 inches
Specifications	4 sets
Design Analysis Estimate	2 sets
Energy Conservation Report (as specified in design criteria)	2 sets
All changed and new electronic files	1 set disks

2.15.3 Title III

With the exclusion of bid sets, the following deliverables are required for Title III review:

Table 2-6 Title III Review

Deliverable	Quantity
Drawings	3 sets D-size, 3 sets 11 inches by 17 inches
Specifications	4 sets
All changed and new electronic files	2 set disks

2.15.4 Post-Title III

The following deliverables are required for Post-Title III review:

Table 2-7 Post-Title Review

Deliverable	Quantity
Drawings, as-built	1 set D-size, 1 sets 11 inches by 17 inches, 2 set disks
All changed and new electronic files	1 set disks

Facilities Engineering returns Title I review marked-up documents for use during Title II. When submitting Title II, return the Title I markups to the SDR, who returns Title II markups for use in making final corrections to the bid documents. The A/E must then return Title II markups along with original drawings for signoff by the SDR.

2.16 Quality Assurance

For each major project, the SNL/CA Project Lead is responsible for developing a Quality Assurance (QA) Plan as defined in the design criteria. The degree of risk identified in the project's Risk Assessment Plan determines the extent of the QA Plan. Typical elements of the plan include, but are not limited to, design documents review and control, construction documents review and control, construction tests and inspections, change order review and control, facility acceptance and transfer, and completed project documents distribution.

Documentation of the quality assurance process is initiated and maintained by the SNL/CA Project Lead. The A/E may be delegated to host part of the process as part of their task.

2.16.1 SNL/CA Facilities Management Quality Assurance Review Process

Line-item projects, general plant projects (GPPs), expense-funded projects with a construction budget of $250,000 or more, and specific projects with unique ES&H requirements require a multidisciplinary QA review including the customer as well as the applicable disciplines listed in the previous section. This review is typically performed during the development of the CDR and the design criteria, and with the submittal of the Title I and Title II designs. The intent of the review is to ensure that the required percent of the design is complete and compliant with all applicable codes and orders. The reviews should also confirm that the customer's requirements are satisfied in the most cost effective manner. This review does not relieve the A/E of the required internal reviews prior to submitting its work to SNL/CA.

There are a number of ways to conduct an effective QA review, including the SNL/CA Project Lead sending the documents to all of the reviewers, providing the documents in a central location at designated times, holding a workshop with the reviewers to present the project and solicit comments, or a combination of these. The SNL/CA Project Lead determines the most effective method to conduct the reviews considering the project budget and schedule. In all instances the SNL/CA Project Lead provides notice to the reviewers of the impending review and sufficient amount of time for review.

2.16.2 Design Package Quality Assurance Review

The Facilities Management design package quality assurance review is initiated by the SNL/CA Project Lead and delivered to the reviewers to record his or her comments.

After all comments have been reviewed, the SNL/CA Project Lead is responsible for resolving conflicting comments and consolidating the responses into a single electronic document to be returned to the A/E.

2.16.3 QA Process and A/E Liability

The QA process is a tool to assist the project team in finding errors and omissions; however, the absence of comments on a specific issue from SNL/CA does not release the A/E from fulfilling all contractual requirements.

2.17 Safety Requirements

The SNL/CA project team members, including SNL/CA Project Lead, operations leads, architects, engineers and other design professionals, must incorporate safety into all project designs to meet current OSHA 1910, 1926, and SNL's corporate requirements for fall protection. All safety related portions of a design, including design drawings, specifications, code footprint, and calculations, must bear the seal, signature, and date of a California-licensed design professional as required and regulated by the California Regulation and Licensing Department's professional discipline Boards.

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
GENERAL DESCRIPTION	**1.** Scope of work narrative **2.** Comparison of capacities (see "Building Interior" for area comparison) to program **3.** List of applicable building codes on drawing title sheet **4.** List of anticipated building code variance requests **5.** Code Abstract – a compilation of all the applicable codes, regulations, ordinances, etc., that are required by governmental agencies having jurisdiction over the Project	**1.** Description of construction phasing **2.** Description of any proposed occupancy within construction area **3**. Building code review (describe means of compliance for major code issues and building systems) **4.** Description of water & vapor characteristics of roof & exterior walls **5.** Design intent document (rough draft)	**1.** Documentation on drawings as required by building codes **2.** If multiple bid packages, clear indication of scope of each release **3.** Identification of construction phasing, including temporary requirements during each phase **4.** Design intent document (completed design)

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
SPECIFICATION	**1.** System & material narrative description	**1.** Outline specification w/same section numbering as final	**1.** Complete specification including draft front end documents **2.** List of items which are sole- sourced or dual-sourced and justification for not specifying three acceptable products **3.** For items listed in "Preferred Manufacturers List", a table of specified items that are NOT indicated in PML and the justification for specifying these items **4.** For door hardware sets that require electricity, indicate the proposed sequence of operations for the hardware

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
SITE	**1.** Site plan(s), to include the following: **2.** Existing conditions **3.** Demolition **4**. Building outline(s) **5.** Future expansion **6.** Site entrance **7.** Roads & driveways **8.** Parking locations **9.** Bus stop/shelter (if required) **10.** Loading dock location **11.** Waste/recycling collection locations **12.** Walkway locations **13.** Stairway locations **14.** Emergency telephones **15.** Utility requirements **16.** Site utilities **17.** Preliminary grading plan **18.** Soil retention work, if needed **19.** Storm water management plan **20.** Preliminary site lighting layout	**1.** General dimensions & elevations **2.** Permanent exterior signage **3.** Parking/roadway plans & elevations **4.** Vehicle & pedestrian traffic controls **5.** Grading plan **6.** Lighting plan **7.** Concept details of site fixtures & equipment **8.** Utility plans, elevations & details **9.** Sanitary sewer flow calculations **10.** Plan to address existing hazardous/contaminated materials, if applicable **11.** Soil erosion and sedimentation control plan (for both construction and occupancy) **12.** Calculation of site and disturbed areas **13.** Dewatering plan	**1.** Extent of construction area **2.** Area traffic plan, if existing roads/walks are impacted **3.** Site development phasing **4.** Construction site access **5.** Staging area **6.** Construction signage **7.** Site details, including landscape **8.** Pipe sizes **9.** Connection details **10.** Copy of local government review comments on utilities and modifications in right(s)-of- way **11.** Photometrics of proposed site lighting **12.** Protection requirements for construction, plantings that remain

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
LANDSCAPING	**1.** Existing conditions **2.** Landscaping concept **3.** Existing irrigation	**1.** Planting plan **2.** Irrigation plan	**1.** Existing tree protection **2.** Soil preparation & planting specifications **3.** Guying diagrams **4.** Piping diagrams **5.** Pipe sizes **6.** Landscape and irrigation details and Legends
STRUCTURAL	**1.** Structural scheme **2.** Written description	**1.** Foundation plan **2.** Typical floor framing plan **3.** Framing plan(s) at unique features **4.** Main member sizing **5.** Structural sections	**1.** Definition of control joints **2.** Beam, column & slab schedules **3.** Mechanical and electrical concrete housekeeping pads **4.** Foundation details **5.** Structural details **6.** Structural notes **7.** Calculations
BUILDING EXTERIOR ENVELOPE	**1.** Typical elevations **2.** Fenestration layout **3.** Material designations **4.** Overall building cross- sections **5.** Roof layout **6.** Energy code requirements	**1.** All building elevations w/dimensional heights **2.** Typical wall sections **3.** Parapet & coping details **4.** Roof & drainage plan **5.** Exterior door details **6.** Typical window details **7.** Details of unique features **8.** Expansion joint locations **9.** Large scale building cross-sections	**1.** Roof-mounted equipment **2.** Roof details **3.** Exterior details **4.** Flashing details **5.** Control joint definition & details

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
BUILDING INTERIOR	**1.** Typical floor plans (min 1/16" scale) w/ legends **2.** Demolition **3.** All room numbers **4.** Area use identification & area in square ft. **5.** Mechanical, electrical & other service closets & rooms **6.** Circulation paths **7.** Area tabulations compared to program requirements **8.** Show flexibility for expansion & alterations **9.** Preliminary layout of major spaces w/ fixed equipment	**1.** All floor plans (min 1/16" scale) **2.** Enlarged plans at elevation changes (such as stairs) **3.** Enlarged plans at toilet rooms **4.** Reflected ceiling plans **5.** Wall types, fire ratings, smoke control zones **6.** Plan to address existing hazardous materials, if applicable **7.** Fixed seating **8.** Defined seating, serving, & kitchen facilities **9.** Equipment & furniture layouts **10.** Important interior elevations **11.** Details of unique features **12.** Details of fixed equipment **13.** Preliminary finish schedule **14.** Preliminary door schedule **15.** Informational signage	**1.** Dimensioned floor plans **2.** Enlarged plans **3.** Partition details **4.** Interior details **5.** Interior elevations **6.** Finish schedules **7.** Door & hardware schedules **8.** Room signage **9.** Schedule of proposed movable equipment that is NOT indicated on documents (for reference) **10.** Schedule of lab fixtures (turrets, etc.), if
ELEVATORS	**1.** Elevator location(s) **2.** Equipment room location(s)	**1.** Elevator shaft section **2.** Equipment description	**1.** Dimensioned plans **2.** Sections & details of hydraulic cylinder, if applicable **3.** Description of shaft sump pit(s) **4.** Elevator car & equipment support details **5.** Description of controls & fixtures **6.** Door & frame details **7.** Interior details including lighting

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
HVAC	**1.** Identify all systems **2.** One-line flow diagrams **3.** Exterior equipment locations **4.** Air intake & discharge locations **5.** Mechanical legend **6.** Special occupancy zones **7.** Energy code requirements **8.** Lab Equipment ventilation system.?	**1.** Updated design criteria for each mechanical system (including room T&H specs, NC levels, etc) **2.** One-line diagrams and other materials as required to describe the fundamental design concept for all mechanical systems **3.** Indication of the amount of redundancy for all major pieces of mechanical equipment, e.g. "two pumps 100% capacity each" **4.** Overall building air flow diagram indicating air handlers, exhaust fans, duct risers, and duct mains **5.** Plans indicating shaft, chase, recess requirements **6.** Duct layout for typical spaces **7.** Equipment schedules (major equipment) **8.** Equipment locations (with enlarged mechanical plan(s)) **9.** Control diagrams (concept form) for all mechanical and plumbing systems	**1.** One line flow diagrams for all mechanical systems: chilled water, hydronic hot water, etc. **2.** Floor plans with all components and required service access areas drawn to actual scale; and on the plans, indicate duct sizes and airflow quantities relative to each room, including CFM in and out of all doors, pipe sizes, materials, flow directions. Indicate location of control panels. **3.** Control valves and volume control boxes (note that each is to be identified by a unique number assigned by the engineer). Provide a schedule that indicates the control sequence that applies to each room (room #, room descriptor, control sequence #). **4.** Detailed floor plans of mechanical rooms w/ all components and required service access areas drawn to actual scale **5.** Cross-sections through mechanical rooms and areas where there are installation/coordination issues (tight space, zoning of utilities). Indicate required service access areas. **6.** In common mechanical space, indication of space zoning by system

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ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
HVAC (cont)		**10.** Description of major sequences of operation **11.** Central automation operation **12.** M/E smoke control scheme **13.** Preliminary calculations **14.** Fume Hoods, Lab equipment ventilation	**7.** Connection to fire alarm &campus control systems drawings, including clear differentiation of trade responsibility for control, fire, and control power wiring; **8.** Equipment details, including structural support requirements **9.** Penetration details **10.** Installation details **11.** Duct construction schedule (on the drawings), indicating materials and pressure class for each duct system **12.** Detailed controls drawings, including clear differentiation of trade responsibility for control, fire, and control power wiring **13.** Detailed sequences of operation **14.** Design calculations **15.** Exhaust system drawings. Details for fume hoods, industrial ventilation systems, , materials, ducts sized for flow/temperature/chemical resistance assumptions.

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
PLUMBING & PIPING	**1.** Main water supply **2.** Restroom location(s) **3.** Plumbing legend **4.** Hydronics **5.** High purity water **6.** specialty gases	**1.** Updated design criteria for each plumbing system (including set points, water quality levels, etc.) **2.** One-line diagrams, etc. that describe the fundamental design concept for all plumbing systems **3.** Piping plans (domestic & process) with indication of required service access areas **4.** Water header diagram **5.** Central cooling water header diagram **6.** compressed air system **7.** lab gases (such as bldg. nitrogen)	**1.** Water riser diagram, including assumed fixture counts per floor connection **2.** Waste and vent riser diagrams including assumed fixture counts per floor connection **3.** Radiation riser diagram **4.** Central cooling water riser diagram **5.** Chilled water riser diagram **6.** Riser diagrams of other plumbing systems, such as natural gas and pure water **7.** Foundation drains **8.** Pipe sizes **9.** Typical plumbing details, including structural support requirements **10.** Water heating piping detail **11.** Coil piping detail **12.** Convector piping detail **13.** Penetration details **14.** Design calculations **15.** Manifold and regulator mount details for gases to include relief valve sizing, vents, solenoids, as required. **16.** Piped vents **17.** Compressors, dryers, filters **18.E**quipment to include pumps, filters, heat exchangers,

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
FIRE PROTECTION (MECHANICAL)	**1.** Report documenting adequacy of utility **2.** Connection to utility **3.** Location of sprinkler valve **4.** Sprinkler legend **5.** Optional Fire Protection systems	**1.** Riser diagram **2.** One-line layout **3.** Fire pump sizing calculations	**1.** Fire protection service entrance details **2.** Fire protection plans (including header and riser layout) with indication of any required service access areas **3.** Pipe sizes **4.** Typical sprinkler installation details, including structural support requirements **5.** Penetration details **6.** Design calculations
LIGHTING		**1.** Typical lighting plans **2.** Fixture/switching layout **3.** Fixture types & schedule **4.** General light fixture descriptions **5.** Light level calculations **6.** Energy code requirements	**1.** Lighting plans, including control devices, switching and circuiting **2.** Control diagrams **3.** Installation details, including structural support requirements **4.** Design calculations **5.** General notes on conduit and wire sizes for all lighting branch circuits.

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
ELECTRIC POWER DISTRIBUTION	**1.** One-line diagrams **2.** Electric vault locations **3.** Exterior equipment locations **4.** Electric closet(s) location(s) **5.** Electric legend	**1.** Normal power riser diagram with circuit breaker & fuse sizes **2.** Emergency power riser diagram with circuit breaker & fuse sizes **3.** Grounding riser diagrams **4.** List of equipment on emergency power **5.** Emergency generator layout **6.** Equipment layout/sizes, w/receptacles **7.** Panel locations/ schedules **8.** Load estimates **9.** Plan for temporary power during construction	**1.** Load summary **2.** Panel schedules **3.** Details of power service to building **4.** Power plans, including power cable trays, electrical loads, special and duplex receptacles, and circuiting. **5.** Plans and details of emergency power generation system and controls **6.** Connections to other building systems, including fire alarm & HVAC systems **7.** Details of special terminal devices **8.** Conduit and wire sizes for services, feeders, and special branch circuits **9.** General notes on conduit and wire sizes for 20 amp single phase branch circuits **10.** Grounding details **11.** MCC details **12.** Penetration details **13.** Design calculations **14.** Electrical Coordination Study (if required)
FIRE ALARM	**1.** Connection to Dept of Public Safety **2.** Panel locations	**1.** Riser diagram **2.** Fire alarm zones **3.** Smoke zones **4.** Device locations	**1.** Indication of connection to fire alarm, HVAC & central campus monitoring systems **2.** Connection details

Table 2-8 Project Deliverables			
ITEM	**Title 1 SCHEMATIC PHASE (30% Completion)**	**Title II (605% Completion) DESIGN DEVELOPMENT PHASE***	**Title II (90%/100% Completion) CONSTRUCTION DOCUMENT PHASE***
COMMUNICATIONS (INCLUDING VOICE, DATA, VIDEO & A/V SYSTEMS)	**1.** Building & local distribution **2.** Frame closet locations & size **3.** Cable tray locations	**1.** Riser diagrams **2.** Voice/data utility outlet locations **3.** All drawings listed in the *Telecommunications Systems Design Manual* that can be accessed on the Standards Program web site. **4.** Conduit and cable tray plans **5.** Material cut-sheets **6.** Description of audio/visual systems **7.** Audio/visual equipment locations (indicate hangers, cabinets & connection boxes)	**1.** Communications plans that indicate the location of all voice, data & video outlets **2.** All drawings listed in the *Telecommunications Systems Design Manual* that can be accessed on the Standards Program web site **3.** Details of telecommunications service to building **4.** Backboard layout & connection diagrams **5.** Cable schedule **6.** Connection details **7.** Structural support requirements **8.** Audio/visual equipment list **9.** Audio/visual system riser diagram(s)
SECURITY SYSTEMS		**1.** General security / CCTV system Description **2.** General description of card access system **3.** Security system riser diagrams **4.** Security equipment locations **5.** Card access equipment closet layout & elevations	**1.** Riser diagrams **2.** Equipment closet layout & elevations **3.** Concealed and exposed raceways **4.** Installation details
OTHER GRAPHICS	**1.** Rendering(s), models, or other graphics as necessary to clearly present concept		

3.0 Civil Design Standards

3.1 Introduction

This chapter describes the criteria, standards, and regulations for designing civil systems at Sandia National Laboratories in California (SNL/CA). These are the minimum acceptable criteria and standards necessary to result in system designs with satisfactory functional characteristics, durability, and operational suitability.

3.2 Construction Drawings

This Chapter describes the various drawings, maps, plans, and profiles required for designing civil systems at SNL/CA.

3.2.1 Area Map and Vicinity Map

Prepare a map to show a zoomed-out view of the project site in relation to its location at SNL/CA. The area map must have a scale of 1 inch = 1 mile or larger. In addition to the area map, prepare a vicinity map to a maximum scale of 1 inch = 200 feet, or as otherwise directed by the Sandia Delegated Representative (SDR). Where applicable, show haul routes, disposal areas, recycle centers, stockpile locations, contractors' access gate, security checkpoints, major street names, and other pertinent information.

3.2.2 Plans and Profiles

Prepare plan and profile sheets for the following:

- Water (domestic and fire protection), storm drain, sanitary sewer, gas, chilled water loops, and recycle/recovery loops
- Electrical overhead and underground electrical conduit runs
- Large cables when pulled into long raceway runs
- Road construction and paving improvements, including utilities within roadways
- Duct banks and buried conduit
- Service laterals

Profiles must have an expanded vertical scale and show the line continuous in profile with break lines to depict change in direction. Run all stationing on plan and profile sheets from left to right regardless of the direction of the north arrow. Draw associated plan views to detail portions of the plan not adequately detailed on the plan portion of the plan and profile. Underground utility profiles must include the vertical locations of existing underground utilities to minimize conflicts. Prepare plans, profiles, or cross-sections to describe paving improvements and extensive grading work adequately. Minor grading and shaping may be shown on a site plan by spot elevations in lieu of a profile.

3.2.3 Site Plans

Prepare site plans to a scale of 1 inch = 20 feet, unless otherwise noted in the design criteria, and orient the plans according to SNL/CA CADD standards. To guide trenching and excavation, show coordination relating to existing underground utilities, architectural features, mechanical equipment, electrical equipment, landscaping (including vegetation and irrigation lines), and other site features that might affect the project on all site plans. Locate the existing underground utilities in the construction area. Use current SNL/CA Topographic Surveys along with a site visit to verify the accuracy of the information. Collect critical measurements during the site visit or secure the services of a surveyor.

3.2.4 Underground Utilities

Develop a plan to locate and document the depth of cover and dimensions of existing underground utilities where it is pertinent to do so along new utility routes and in areas to be excavated or graded.

Provide utility locating methods and services as indicated in the project scope. Services may include potholing using vacuum excavation or ground-penetrating radar as required to properly design the project. Follow SNL/CA CADD standards to up-to-date existing site data files.

Add the following note to the general notes section of the title sheet for projects that include existing underground utilities work: Caution When Excavating. The locations of all underground utilities shown are approximate. The contractor must verify the horizontal and vertical location of all underground utilities prior to the start of construction. The contractor must not interfere with utility line operations and must coordinate all work affecting existing utilities with SNL/CA for each utility, and must notify the SNL/CA Construction Manager (CM) promptly of any problems or conflicts encountered. Further, the contractor must obtain excavation permit prior to start of excavation. See the project specifications for other requirements.

3.2.5 Drawings Required for Construction

The following chapters provide lists of drawings required for a typical project. To illustrate the scope of a project, an approximate list of the plans and drawings required is provided in the design criteria for each discipline. The CADD design files for all projects must conform to the requirements of the CADD Standards Manual. Infrastructure drawings and organization within the construction drawings set include, but are not limited to, the following:

- Title Sheet: Include job title, project number, contract number, vicinity map, and index of drawings. If the index is extensive it may be placed on a separate Index of Drawings sheet.
- Vicinity Map: Map showing a zoomed-out view of the project site in relation to its location on SNL/CA at a scale of 1 inch = 1 mile or larger.
- Site Layout Plan: Show general notes, limits of construction, fences, access, storage areas, street names, alignment of temporary fencing enclosing work areas, and other items needed to convey accurately this portion of the design to the contractor. Provide SNL/CA control monuments with ties to new construction, if a site survey is not provided in the design drawings.
- Traffic Control Plan: Provide traffic control for pedestrian and vehicular traffic phased with the demolition and construction activities of the project.
- Removal or Demolition Plan: Show all existing facilities and infrastructure to be removed and pertinent phasing. If required for modifications work, include a site survey.

- Grading Plan: Show the buildings considered in the contract, the surrounding area, existing topography (including contours at an appropriate interval), and required elevations referenced to an existing benchmark. Show finished grading and existing grades to determine cut and fill. Show street centerlines properly referenced to the coordinate system. Show utilities, unless separate utility site plans are included in the set.
- Drainage Plan: Show drainage basins, flow paths, rates, and finished contours unless submitted in a separate drainage report.
- Storm Water Pollution Prevention (SWPP) plan per Chapter 3.4.5.
- Exterior Utilities Plan: Show all existing and new utilities, including irrigation lines, where feasible. Include a legend for all existing and proposed utilities.
- Plan and Profile Drawings: Provide plan and profile drawings for all utilities unless otherwise directed by the Infrastructure Engineer. Show the plan and profile of road construction, as well as survey data and the existing grade at centerline (not required for short access or service drives). Show the plan and profile of new utilities as well as existing and finished grades at centerline.
- Detail Sheets and Area Plans: For road construction, show typical roadway cross- section, intersection plan with spot elevations as needed, turnouts, special paving area plans, pavement section details, and structure details. For utilities, show all special connections, utility vaults, or other information that cannot be shown on the utility plans and profiles.
- Cross-Section Sheets: For road construction, cut and fill cross-sections at specified stations when requested by the SDR.
- Exterior Civil Details: Provide reference to standard details or show details for civil site work. All details must be labeled descriptively, and cross-referenced to the applicable plan drawings. See the CADD standards for additional CADD requirements.
- Site planting and Irrigation Plans and Details: Show all required information on separate sheets.

3.3 Site Modification Review and NEPA Review Process

Projects at SNL/CA must give consideration to the environment early in the project planning stage. This consideration is documented through the National Environmental Protection Act (NEPA) module of the Integrated Safety Management System (ISMS). Requirements for complying with NEPA regulations are found in corporate procedure ESH100.1.EP.2, Implement NEPA, Cultural Resources, and Historic Properties Requirements. Construction activities within 100 feet of any monitoring well must be coordinated with the SNL/CA Groundwater Protection Program Project Lead. Soil-disturbing construction activities are prohibited with 50 feet of any monitoring well. Any borehole installation within half the distance from the ground surface to the uppermost occurrence of groundwater must be coordinated with the SNL/CA Groundwater Protection Program Project Lead.

3.4 Exterior Utilities

Size and terminate utility systems to accommodate future connections. Extend utilities to the edge of the site or to a point where connection can be made without damage or disruption to the utility or adjacent structures. Establish utility corridors with each utility having a defined location within the corridor to optimize land use and provide adequate utility separation.

3.4.1 Underground Water Lines for Domestic and Fire Protection Systems

The following subsection describes criteria and standards for the design of water distribution systems. It does not cover the criteria necessary for the design of major transmission lines, wells, pumping facilities, or reservoirs. Advance approval is required for modifications from the following criteria:

- Water lines and connections to existing water lines must be designed and shown on a plan and profile drawing. Drawings must show all details, including required fittings and joint restraints.
- Locate distribution lines in a utility corridor whenever possible.
- All lines must comply with SNL/CA standard specifications and standard drawings.
- Service laterals must be sized according to the code requirements for the facility. Branches off the main water line must have a gate valve in a valve box to isolate the building or facility from the main. Where possible, the potable water service is to be a branch off the fire service line, with its own gate valve in a yard box.
- The minimum depth of cover over all water lines is 36 inches unless specified otherwise in SNL/CA Standard Specification contained in Division 22, Plumbing and Division 33, Utilities.
- The trench for pipe installation must be similar to Type 4 as defined by American Water Works Association (AWWA) C600. Pipe must be bedded in 4 inches of sand, gravel, or crushed stone. Backfill must be compacted to the top of the pipe to approximately 80 percent Standard Proctor, American Association of State Highway and Transportation Officials (AASHTO) T-99.
- Connections larger than 2 inches must be made by cutting the supply main and inserting a standard tee. The maximum allowable tap using a tapping saddle is 2 inches. Connections larger than 2 inches, tapping sleeves must be used. The size of the tapping sleeve is limited to one half of the nominal pipe diameter. Connections exceeding this requirement must be made by inserting a tee. See SNL Standard Specification 331116, Site Domestic Water System, and 331119, Site Fire Water System, for additional tapping requirements.
- When the water main supply line is 8 inches or larger, the minimum size fire protection line is 8 inches for any sprinkler system supplying a building designed for Ordinary Hazard Group II or greater. Buildings, T-buildings, mobile offices, and trailers smaller than 10,000 square feet are exempt from the 8- inch- minimum fire line requirement.
- Do not run fire protection mains under buildings, including temporary structures, such as mobile offices or trailers.
- Locate post-indicator valves (PIVs) on fire protection lines no closer than 40 feet and no farther than 100 feet from the building. Post-indicator valve supervisory switches must be installed for all PIVs and connected to the building fire alarm system. The devices must be electrical; single-pole, double-throw, with normally closed contacts and include design that signals the controlled post-indicator valve is in other than a fully open position.
- Three-way fire hydrants with a curb box valve must be provided within 50 feet of all fire department connections. Fire hydrant spacing must not exceed 300- foot intervals.
- All pipes passing under railroad tracks must be encased in a protective metal sleeve, sized at least 2 inches larger in diameter than the water line. Support the pipe in the sleeve per manufacturer's instructions. Seal the ends of the sleeve with resilient caulking material or a preformed plastic boot.

- Mechanically restrained joints must be designed and detailed on the construction drawings.
- The design of valves within the water system must conform to the following criteria:
  - Valve Spacing
    - 1,000 feet maximum between inline valves for lines 16 inches and large
    - 600 feet maximum between inline valves for lines 14 inches and smaller
  - At the intersection of water lines, the distribution lines in all directions must be valved
  - Fire hydrant legs from mains must be valved
  - Valve Location: Avoid locating valves under parking spaces or locations where the valves might be inaccessible, in sidewalk ramps, and next to fences.
  - Valve Types
    - Valves 12 inches and smaller must be gate valves
    - Valves 14 inches and larger must be butterfly valves
  - Valve Sizing
    - All valves must be the same size as the main lines
  - Air-Relief Valves
    - No air-relief valves or air-relief hydrants are required on lines 8 inches or smaller where there are services on the line. On distribution lines greater than 8 inches, sizing and location of air relief hydrants must be coordinated with Sandia N/CA

3.4.2 Natural Gas

This subsection describes criteria and standards for the design of natural gas distribution systems. Consult with the SNL/CA Project Lead in advance for approval of any departure from the criteria.

The SNL/CA natural gas distribution systems are operated at a nominal pressure of 20 psi. Designs should allow for a future pressure capability of 60 psi. The size component for a local atmospheric pressure is 12.12 psia.

All gas lines and their connections to existing gas lines must be designed and shown on plan and profile drawing. Drawings must show all details, including required components and fittings. Gas system designs must meet all applicable codes and requirements. Consult with the SNL/CA Project Lead for planning and system modeling of all gas distribution work.

All pipes and valves are to be high-density polyethylene piping in accordance with the SNL/CA Standard Specifications and Standard Drawings. Butt-fusion connections to existing piping or dissimilar materials are not allowed; these connections must be made with an electro-fusion coupling.

Use an anodeless riser followed by an insulating union in accordance with SNL/CA standard drawings to isolate electrically the above ground and below ground gas systems. Use of tapping saddles requires approval from SNL/CA.

Test ports are required for line spot purposes at all major direction changes or every 200 feet, whichever distance is lesser. If the spanned distance is less than 400 feet, but more than 200 feet, split the distance to allow equal spacing between the test ports.

Use marker post-test boxes in remote locations. Size the natural gas main lines based on requirements from SNL/CA. Size building feeds according to the design code and service load requirements of the facility. Size the piping past the building regulator in accordance with the latest revisions of NFPA 54, National Fuel Gas Code. Branches off of the main gas line must have a ball valve in a valve box to isolate the building or facility from the gas main.

The minimum depth of cover over all gas lines must be 36 inches. The trench for pipe installation must be in accordance with the manufacturer instructions and recommendations for the pipe installed. Install the regulator/meter assembly outside of the building.

A regulator is required to control the pressure between the gas distribution grid and the gas meter; this regulator must be rated for 60 psi minimum pressure and may be set at pressures up to 15 psi to allow greater utilization of meter capacity. The final regulator before the service feed enters the building must be spring operated with built-in relief protection and an insect screen. Building gas meters must be installed with a minimum pressure rating of 25 psi. Choose the meter type based on required meter capacity.

The meter should have an odometer type head for reading cumulative gas usage and must be connected to the FCS system or configured with a Mercury Mini Max ATX corrector head for data recording purposes.

Regulator/meter assemblies that are configured with a corrector head must also be configured with the required pressure and temperature sensors. Meter selections must be approved by the SNL/CA Gas System Engineer. Obtain approval from the SNL/CA Gas System Engineer and the Fire Protection Engineer to use gas pressure exceeding 14 inches water column inside the building. The regulator/meter assembly must be protected from vehicle damage.

During construction phasing a cap, connected using electro-fusion, must be installed on any open pipe prior to energizing the pipe during phasing activity. New pipelines may not be energized with natural gas while open to the atmosphere. All abandoned pipes left in the ground must be purged with air and plugged or capped.

The design of valves within the gas system must conform to the following criteria:

- At the intersection of gas lines, the distribution lines in all directions must have an in-line valve
- Valve Location: Avoid locating valves under parking spaces or locations where valves might be inaccessible, in sidewalk ramps, and next to fences
- Valve Type: Valves must be high-density polyethylene ball valves
- Valve size: All valves must be the line size full-port valves

3.4.3 Liquefied Petroleum Gas

Provide heating energy to areas remote from natural gas distribution using a liquefied petroleum gas system. All installations must meet the requirements of NFPA 58, Liquefied Petroleum Gas Code. Size the tank for 30-day storage for the maximum-degree day and to ensure that the tank will supply adequate cold day gas to meet the demand of the facility it is servicing. Consider the composition of the liquid locally distributed during the winter when sizing the tank.

Locate a regulator, relief valve, capacity gauge, and fill valve under a protective cover on the top of the tank. The exterior regulator must have an automatic shutdown device for excess flow conditions. Select line and regulator size to prevent freeze-up during cold weather usage. Specify an American Gas Association 100-percent shutoff safety pilot and appliance regulator on all appliances.

3.4.4 Storm Drains

Storm drain design must comply with local municipal requirements and the following technical guidance:

- Hydrology

- Hydraulic Design
- Channel Treatment Selection Guidelines
- Design Grading and Erosion Control
- Miscellaneous

3.4.5 Storm Water Quality

Projects shall comply with the current version of the Provision C.3 of the California Regional Water Quality Control Board San Francisco Bay Region Municipal Regional Stormwater NPDES Permit (MRP) as administered by the Alameda County Clean Water Program.

3.5 Site Work

3.5.1 Grading

Prepare a current topographic survey for all construction projects when grading or trenching is required. Plan topography with a grading minimum and preserve the site character in an efficient and economical manner. Site grading must minimize site disturbance by emphasizing conservation of existing natural areas and restoration of previously damaged areas.

In the site grading design provide for adequate surface drainage and preservation of natural terrain by allowing a minimum of earth movement with the objective of balancing cut and fill. To prevent surface drainage from entering or ponding adjacent to the structure, place finished floor elevations with access penetrations sufficiently above the existing ground gradient or the roadway grade. Write an accompanying drainage report to prove these criteria.

In the site grading design, take into account the need for safety and ease of personnel and vehicular access to the facility. Design the outside finished grade to slope away from the building at a 5-percent grade for the first 10 feet unless otherwise approved. Extend the 5-percent grade to 20 or 30 feet in areas with highly expansive soil. When site conditions require the use of steep slopes near buildings, provide an area that is at least 6 feet wide at a 5-percent grade away from the building. Indicate these requirements on the grading plan with critical spot elevations and finished contours. When the adjacent outside grade is brought above the building floor level for energy conservation, aesthetic, or economic reasons, design the outside finish grade to slope away from the building at a 20 percent minimum grade for at least 5 feet.

3.5.2 Fencing

Security fencing is required as a physical demarcation of a security area, for security of classified assets and government property, and to direct flow of personnel and vehicles through designated entry control points. Fire department access must be provided during construction and occupancy phases when designing temporary and permanent fencing.

Fences to be used for security purposes must be at least 8-feet high, with fabric a minimum of 11-gauge galvanized steel, and with mesh openings a maximum of 2 inches on each side. The fence must be topped by a minimum of 3 strands of barbed wire on single or double outriggers. Single outriggers must be angled outward from the security area. Double outriggers must be used at Protected Area boundaries. Security fencing must extend to within 2 inches of firm ground or extend below the surface,

if the soil is unstable or subject to erosion. Alternative security fencing is allowed with approval from Physical Security. Alternative fencing must meet the penetration resistance of the standard chain link security fencing penetration resistance for alternative fencing must be submitted for approval to Physical Security prior to contract acceptance.

Posts bracing and other structural members must be located on the inside of security fences. Wire ties must be of equal tensile strength as that of the fabric. Locate security fencing with a clear zone along each side of the fence to facilitate intrusion detection and prevent bridging over the fence. Fence must be located a minimum of 20 feet from structures or assets located inside the security area and a minimum of 20 feet from structures located outside the security area. Landscaping must be designed such that plant growth does not impede visual assessment or allow bridging. Consult with a Physical Security representative for the latest standoff requirements.

3.5.3 Gates and Turnstiles

Location of turnstiles and motorized gates must be coordinated with SNL/CA to ensure adequate automated access control and other system support.

Use swinging gates for access through security fencing. Use swing gates in other fencing when possible. When rolling gates are required, use a system with an overhead support, if practical. If a cantilevered gate must be used, use a system with an enclosed top rail as a track.

Avoid using rollers at grade because dust and water accumulations are a constant maintenance problem. Gate hardware for security fencing must be brazed, peened, or welded to prevent removal. Use turnstiles for pedestrian entry control points. A minimum of two single turnstiles and one bypass gate must be used at each entry location, unless within line of sight of another entry point. Tandem turnstiles must not be used because of safety and maintenance concerns.

3.5.4 Sidewalks

Design sidewalks and walk gradients to provide safe and convenient access, egress, and circulation between facilities. Base the width of sidewalks on anticipated traffic, with a minimum width of 6 feet increasing in 2-foot increments. Sidewalks paralleling curbs in parking areas and those with high pedestrian use must have a minimum width of 6 feet of available walking area. All sidewalk widths must be consistent with accessibility requirements. Where Federal and State accessibility requirements differ, the more stringent requirement shall apply. Install ramps where required to maintain accessible routes.

Integrate sidewalk design with drainage system and landscape design as much as possible to promote collection, conveyance, and infiltration of storm water runoff generated from continuous, impervious sidewalk surfaces. In addition, prevent sidewalks from contributing to heat island effects by providing shade from landscaping or locating sidewalks in areas not subject to sustained sunlight.

3.5.5 Dual Bicycle and Cart Paths

Bicycle and cart paths must be separated from pedestrian sidewalks. The paths must have a minimum width of 12 feet for two-way traffic and 8 feet for one-way traffic, a maximum longitudinal slope of 5%, and a maximum cross slope of 2%.

3.5.6 Roads

When designing roads and associated drainage systems, take into account soil, geologic, topographic, and climatic conditions, including any special conditions, such as snow removal. Roadways must be designed to accommodate the maximum size of vehicles traveling through the area. During planning and design, carefully consider the timing of road construction, specifically for seasonal conditions. Flexible pavements and curb and gutter must be in accordance with approved standard drawings.

If required, perform a traffic analysis to estimate the volume and character of traffic during both the construction and operating phases. Controlling vehicle speed within congested areas can permit the profile of roads to conform generally to the ground surface, which allows maximum use of adjacent areas and results in economical road construction costs. SNL/CA determines speed limits. Reserve sufficient corridor width for future expansion. Design and plan underground utilities and their construction to minimize interference with road construction and trench cuts in recently paved areas.

Integrate road design with drainage system and landscape design. Consider landscaping and other suitable means of harvesting runoff from roads to promote collection, conveyance, and infiltration into the soil. For environmental protection, provide adequate drainage and soil stabilization for roads and construction areas. In addition, carefully maintain roadways, ditches, and drainage structures during construction. Design of emergency vehicle access must conform to fire lane requirements.

3.5.7 Parking

Locate parking areas to blend into the background of the building complex without detracting from the principal structures. Avoid siting parking areas in front of buildings and at prominent visual points of approach. Provide accessible pathways and parking with space designators and emergency access. Emphasize attractive features and de-emphasize or obscure undesirable features when designing landscaping, grading, and locations. For parking stall dimensions and other requirements see the Campus Design Guidelines.

Parking system design must be integrated with the drainage system design and landscape design. Parking systems should be designed to minimize generation of storm water runoff, harvest storm water for landscape irrigation, and prevent the formation of heat islands. Avoid large continuous parking areas that generate storm water runoff and become heat islands during summer months. Consider smaller connected parking areas separated by landscaping that provides runoff management. Include landscape provisions (in the form of trees) to ensure that at least 30 percent of parking areas are shaded within 5 years of project completion.

Provide perimeter concrete curbs and gutters for all parking areas and access drives in built-up areas. Consider directing runoff to infiltration areas, such as medians or adjacent planting areas. Such water-harvesting areas must be designed and planted to accommodate occasional flooding. Direct the storm water runoff into the storm drain only when the capacity for onsite management is exceeded. In remote or infrequently used areas, use concrete curbs and gutters only when required to control drainage.

To provide positive surface drainage, design pavement grades with the following:

- 1/2-percent absolute minimum slope in the direction of drainage; use greater slopes wherever possible
- 5-percent maximum slope in all directions for bituminous or concrete surfaces
- 2-percent maximum slope in all directions for handicapped-accessible parking spaces and access aisles

During planning and design, consider the following factors when determining vehicle parking requirements:

- Occupancy of the facility to be served
- Provisions for physically handicapped persons
- Preferred parking for carpools and vanpools Service vehicle and visitor parking needs Single facility parking areas versus joint-use parking for adjacent facilities
- Aesthetics (siting, landscaping)
- Location of fire-protection devices (hydrants, pumper connections) and accessibility for emergency vehicles
- Facilities for motorcycle and bicycle parking
- Garbage truck access
- Provisions for pedestrian traffic. Orientation of the parking rows should promote pedestrian travel in a manner that minimizes the need for pedestrians to cross through other parking rows to obtain access to pedestrians' paths
- Provide identifiable pedestrian routes parallel to vehicular traffic within the parking lot. Provide designated pedestrians paths at key points across rows when necessary to move pedestrians towards pedestrian paths leading from the parking area
- Provide painted parking stalls to the dimensions indicated in the Campus Design
- Guidelines. Avoid the use of parking bumpers
- Pedestrian walkways may also serve as curb stops. Concrete sidewalk must be 6 inches above parking lot grade, and must be of sufficient width to convey the anticipated number of pedestrians and provide for vehicle overhang with a minimum of 6 feet of available walking area
- Appropriate distance from perimeter fencing (see chapter 11, "Security Design Standards.")

3.5.8 Landscape

Landscape development shall be in accordance with Chapter 4.0, Landscape Design.

3.5.9 Removing Utilities

Apply the following guidance when removing utilities from service or encountering abandoned utilities:

- If an entire site is being cleared, remove the utility within the entire confines to be cleared
- If the utility extends beyond that confine and crosses sidewalks and roadways, remove the portions inside the site and abandon in place those portions offsite
- If a roadway or sidewalk is cut open for construction work and an abandoned utility is exposed (or abandoned by that project), remove exposed portions
- If roadways or sidewalks that would otherwise not be cut would be cut to remove, then abandon in place
- Check the system configuration to see if there are advantages or disadvantages to either removal or abandonment
- Minimize surface disturbance to the extent practical and ensure protection of adjacent natural or landscaped areas

- Remove all abandoned valves, and cap the mains or the service laterals at the fitting in the main

3.6 Drainage Requirements

A drainage plan is required for all development or redevelopment projects at SNL/CA that must implement the storm water runoff requirements of section 438 of the Energy Independence and Security Act (EISA) as further explained in subsection 3.6.2 of this Design Standards Manual. A drainage plan is also required for any project that has drainage improvements unless an exception is provided.

Design the drainage system layout to best meet the operational requirements of the facility and the requirements in this chapter. Design all new storm drain systems to convey a 10- year, 24-hour storm. The system should be economical and efficient while considering the following:

- EISA requirements
- Flooding protection requirements
- Topography
- Ultimate development of the drainage area
- Outfall locations
- Downstream capacities and effects on surrounding facilities
- Coordination with underground utilities
- National Pollutant Discharge Elimination System
- Hydrology
- Hydraulics

Where applicable, drainage system design should promote infiltration into the soil by incorporating provisions for onsite collection, conveyance, and containment in coordination with the EISA requirements. Consider integration of the drainage system design with other aspects of the facility design to limit the disruption of natural water flows by minimizing the generation of storm water runoff, increasing onsite containment and infiltration of storm water into the soil, and reducing contamination in storm water that must be conveyed offsite.

Drainage system design-integration measures that should be considered include, but are not limited to, the following:

- Roof drainage: Incorporate roof drainage into the overall drainage system design. Refrain from integrating the roof system directly with the storm drain unless no other onsite containment method is feasible.
- Landscaping: Incorporate landscaping features that collect, convey, contain, and promote infiltration of storm water into the soil. Include rainwater harvesting in the irrigation design for landscaping when practical.
- Parking, roadway, and sidewalk: Minimize impervious surfaces that generate storm water runoff. Minimize the use of storm drain inlets, except to accommodate overflow from onsite containment capacity. Separating parking rows with landscaping that can collect, convey, contain, and infiltrate runoff into the soil.

3.6.1 Flooding Requirements

All facilities are to be protected from flooding according to the Department of Energy Standard DOE-STD-1020-2012, Natural Phenomena Hazards Design Criteria for Department of Energy Facilities, and all updates; a section of the standard is dedicated to flooding hazards. Finished floor elevations and other applicable facility elements are to be set or designed consistent with the requirements of the standard. The flood protection requirements in the standard are based upon the Performance Category of the facility being designed. That Performance Category is to be obtained from the SNL/CA Project Lead. As a reference, Performance Category 1 facilities are the least restrictive and are required to be protected from a 500-year-frequency storm event.

Flooding effects on existing adjacent and downstream facilities that are a result of the facility being designed are to be considered during the design process. Any increased flooding effects on existing adjacent and downstream facilities that are a result of the facility being designed are to be mitigated as part of the design and construction process. Mitigation is required if the existing adjacent and downstream facilities no longer meet the requirements of the standard or if the increase in the flooding effects reduces the functionality of the existing adjacent and downstream facilities. The design must meet local municipal requirements. Whenever a conflict exists between the maniple requirements and the standard, the more stringent of the two requirements applies.

3.6.2 National Pollutant Discharge Elimination System Permitting

All construction sites that disturb an area of one acre or more are subject to National Pollutant Discharge Elimination System (NPDES) permitting requirements. Specifically, most construction projects fall under the jurisdiction of the most recent edition of the NPDES General Permit for Storm Water Discharges from Construction Activities. The permit is titled National Pollutant Discharge Elimination System General Permit for Discharges from Large and Small Construction Activities. To determine the applicability of NPDES permitting requirements, the disturbed area associated with a construction site is defined as follows: "The physical location of the new facility with any utility extensions, haul roads, stockpile areas, staging areas, and any additional area disturbed by the construction."

Include site-specific interim and permanent stabilization, managerial and structural solids, erosion- and sediment-control, and other controls designed to prevent an increase in the sediment yield and flow velocity from preconstruction, undisturbed conditions. Erosion control techniques for interim stabilization may include silt fencing, bale barriers, earthen berms, sediment ponds, stabilized entrances to the construction site; or other acceptable erosion control practices. Erosion control practices for permanent stabilization might include reseeding, final site grading, and permanent surface stabilization, such as paved surfaces, landscaping treatments, and graveled areas or other engineered solutions appropriate for permanent stabilization.

Small construction sites of one to five acres may be eligible for a waiver, if the requirements in NPDES permit Appendix D, "Small Construction Waivers and Instructions," can be met. Additional guidance related to NPDES permitting requirements can be found at the following web address: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm

Develop the SWPPP and the SCP based on the requirements of the NPDES General Permit, and submit the documents to the SNL/CA Project Lead for review and approval during the design phase of a project, or must determine if SNL is eligible for a waiver. The SNL/CA Project Lead must submit the final SWPPP to the Environmental Programs and Assurance for review and coordination of final approval. Upon review and final approval of the SWPPP document coordinates the submittal of a Notice of Intent

(NOI) to the Environmental Protection Agency. Both SNL and the construction contractor are required to submit NOIs. The permit does not become effective until seven days after the EPA posts the NOI on its web site.

Once the construction contract has been awarded, the contractor must adopt the SWPPP and SCP developed for the project as required. The contractor may elect to provide its own SWPPP and SCP, but this action must be approved by SNL, and the contractors' SWPPP must be developed to the same standard as the SWPPP developed for SNL/CA. Construction work must not commence prior to meeting all of the NPDES permit requirements. Further guidance on development of SWPPPs and SCPs can be obtained from the SNL/CA Project Lead, as well as the EPA web site.

All projects shall comply with the latest version of the NPDES General Permit for Storm Water Discharges from Construction Activities.

3.6.3 Hydraulic Design of Closed Conduits and Open Channels

Storm-drainage systems include streets, storm drains, and open channels (borrow ditches, earth channels and armored channels). Show flow (Q), velocity (V), hydraulic grade line (HGL), and upon request, the energy grade line (EGL) on the construction drawings for all storm-drainage systems. Keep this information on the construction drawings, and file it with the construction set for reference.

Design closed-conduit systems (including pipe, box, or arch sections) as flowing full and, whenever possible, under pressure. When designing a proposed conduit for pressure condition, do not allow the hydraulic grade line to be higher than the ground or street surface at the design flow. Typically design lateral pipes entering a main line pipe storm drain to use standard precast wye fittings.

The minimum diameter of the main-line conduit must be 18 inches. The minimum slope for the main-line conduit must be 0.005 feet per foot, and the minimum flow velocity must be 3 feet per second during conveyance of the design flow. If warranted by existing circumstances, the main-line slope may be flatter than 0.005 feet per foot if approved by SNL/CA.

Construct open channels only in locations approved by the SNL/CA Project Lead responsible for storm drains. In general, to allow for the interception of surface flows, design all open channels with the tops of the walls or levees at or below the adjacent ground. For unlined open channels, the mean velocity must not exceed 3 feet per second. Determine maximum side slopes for the channel based on an accompanying soils report. In general, the side slopes should not exceed 3:1 (H:V).

When a storm drain outlets into a natural channel or unlined channel, provide an outlet structure to prevent erosion. The minimum requirements are a headwall and appropriate riprap including a wire-enclosed riprap blanket.

Street drainage is usually accomplished by the use of curbs, gutters, and inlets. Consider curb gaps in areas where roadside ditches are used. As a general rule, the streets should be clear during a 10-year storm and checked for adequate capacity during larger storms up to and including a 100-year event. Do not use inverted crown sections for streets without prior approval. Do not locate curb inlets in the radii of street intersections or where pedestrian traffic is most likely to occur.

3.7 Surveying

This chapter defines the types of surveying and established minimum requirements governing the performance of survey-related services by professional surveyors performing work for SNL/CA. Surveys

must be coordinated through SNL/CA. Surveying control data may be obtained from the SNL/CA department.

Topographic or design surveys must indicate the horizontal and vertical locations of all surface features. Underground utilities must be shown in their horizontal location. Sanitary sewer manholes and storm drain inlets and manholes must include vertical data based on measurements from the rim or grate to inverts of pipes. The locations of valve boxes, fire hydrants, post indicators, and other appurtenances for water, heating, and cooling lines must be shown, as well as power poles and clearance at sag of overhead utility lines. Underground communication lines, power lines, and other appurtenances must be indicated. Provide all applicable information on the construction drawings.

Surveys must be coordinated with the SNL/CA Utility Coordinator to assure that underground utility lines are clearly spotted on the ground prior to commencing the survey. Line spots performed by SNL/CA must be in accordance with accepted standards for the color coding of utilities. Survey personnel must be familiar with these standards and reflect the appropriate utility based on the color coding. Pavement cuts must not be used as an indicator of an underground utility location.

Contour intervals must be 1 foot unless otherwise specified. Sufficient spot elevations must be provided to assure that drainage patterns are evident. The vertical accuracy of 90 percent of the points tested must be within one half of the contour interval, unless otherwise stated on the survey.

Monuments set by the surveyor must be ferrous metal, at least 0.5 inches in diameter and at least 16 inches long. They must bear a metal or plastic cap stamped with the surveyor's registration number. Control monuments at SNL/CA must be set in accordance with accepted standard drawings for installation of brass caps.

The surveyor must submit a completed Monument of Record form for each monument established. The form can be obtained from Infrastructure Engineering. Corners that fall upon a hard surface must be installed with a chiseled cross or a nail in a disk or tag bearing the surveyor's registration number. When a corner is located at a place where it is not practical to set a monument or a monument is at risk of being destroyed, at least one reference monument must be set and dimensioned on the plat such that the location can be reestablished.

Monuments shall be set and documented in accordance with the requirements of Alameda County. Monuments shall not be destroyed.

3.8 Sewer Design Standards and Procedures

This Chapter sets forth criteria to be used in the planning and design of sanitary sewer infrastructure to support development of new facilities within the property at SNL/CA. All work outside the property shall be completed in accordance with the City of Livermore's standards. For the purpose of this Chapter, sanitary sewers convey wastewater suitable for disposal in the municipal collection system; the flow shall be free of hazardous materials.

For new development, the Project Engineer shall use this as a guide to estimate the quantity of sanitary sewer flow and size the pipelines to convey this flow. Additionally, the Project Engineer shall confirm that existing downstream pipelines have the capacity to accommodate the increase in flow. The sewer system components may consist of gravity sewers, pump stations, force mains, and related appurtenances.

In some cases, the SNL/CA Project Lead, may direct the Project Engineer to specify brand names to match existing equipment or for safety and maintenance-related reasons. In such cases, the Project Engineer shall specify the brand names of the designated manufacturers.

The focus of this *Sewer Design Guide* is the design of gravity sewer systems at SNL/CA, which may include small pump stations. It should be understood that the design of a pump station will require specifications in other disciplines such as civil, structural, electrical, mechanical, and architectural.

The Project Engineer should use the SNL/CA Standard Specifications by the Project Engineer, as applicable to their project. There may be other project specifications not covered by this *Sewer Design Guide* or by the SNL/CA Standard Specifications. It shall be the responsibility of the Project Engineer to develop these specifications and those for other project disciplines. When using the referenced Design Standards and SNL/CA Standard Specifications, it is the responsibility of the Project Engineer to modify or provide design documents adequate to meet the needs of each specific project.

Definitions

Mains are gravity sewers that collect flows from collector lines that discharge to the municipal system.

Collector lines are gravity sewer mains that collect flow from service laterals.

Service laterals connect building waste plumbing to the collector lines.

Force mains are pipes conveying flows from lift stations under pressure.

Inverted siphons are gravity mains flowing full under pressure due to a sag designed into the pipe profile between inlet and outlet.

3.9 Sanitary Sewer System Planning

This Chapter covers criteria for estimating wastewater flows, pipe sizing, separation of sewers from other utilities, and basic criteria for planning sewer pump stations. An approved sewer planning study shall identify pipe diameters and alignments of all proposed and existing sewer mains and shall include a summary of the estimated sewer flows, hydraulic calculations, separation of mains, capacity, depth, and slope of pipelines, and maps. The design, location, and installation of sewer systems can substantially affect quality of life, safety, and the environment.

As a result, the design of sewer systems must be an integral part of the overall planning effort early on in the life of a project. Where good design alone cannot satisfy the needs and engineering requirements of SNL/CA, the Engineer will work with the SNL/CA Project Lead to resolve conflicts, which may arise.

3.9.1 Preliminary Project Planning

3.9.1.1 Alignment and Grade of Mains

3.9.1.1.1 New Mains

New Mains shall be designed to accommodate gravity sewer facilities shall be located within a street, wherever possible. The depth of the sewer shall be as required to accommodate the current and future uses; excessively deep pipelines are to be avoided.

Where new sewers must be located in environmentally sensitive lands, pipeline planning, design, construction and requirements of the Maintenance Access Plan shall comply with SNL/CA's environmental policies to the greatest extent possible.

Pipelines shall generally be installed by open trenching. However, if there are physical, topographic, environmental, or other constraints present, the Project Engineer may use trenchless methods including

directional drilling, micro tunneling, pipe ramming, jack and bore, or alternative methods as approved by SNL/CA. When using trenchless methods, the Project Engineer should consider increasing the pipe slope to as grade control can be a challenge.

3.9.1.2 Relocated Mains

Sewer mains installed to replace existing facilities in existing developed areas shall generally follow existing alignments, but may be realigned as deemed necessary to achieve optimum flow conditions, reasonable access, and separation from existing utility infrastructures. Where possible, all sewer mains shall be located in streets.

If an adjacent sewer is located in open space, the project shall relocate the sewer main within the limits of the project where possible. Where existing sewers are located in environmentally sensitive lands, pipeline planning, design, construction and requirements of the Maintenance Access Plan shall comply with SNL/CA's environmental policies to the greatest extent possible.

3.9.1.3 Precedence of Sewer Facilities

When a project and/or portion of a project cannot be reasonably designed to meet the requirements listed above, the sewer system shall be designed with the following types of facilities, listed below in order of precedence:

a. Gravity sewers in paved streets, alleys, or parking lots.
b. Pump stations or gravity sewers in environmentally sensitive areas with permanent sewer access roads provided. In such cases, the designer shall ensure the project complies with the requirements of SNL/CA's environmental policies to the greatest extent possible.

3.9.1.4 Pump Station Location

New developments shall be designed to eliminate the need for pump stations whenever possible. However, in environmentally sensitive lands, the need for a pump station shall be considered against other options in conformity with SNL/CA's environmental policies.

3.9.1.5 Sewers in Environmentally Sensitive Lands

Sewer mains in environmentally sensitive areas shall be limited. However, if such areas must be impacted, the Project Engineer shall consult with the SNL/CA Project Lead, and consider the following:

a. As development occurs, existing sewers in environmentally sensitive areas shall be relocated to streets or other appropriate areas where possible.
b. Consider installing the pipeline using trenchless methods.

3.9.2 Planning Study

3.9.2.1 General Requirements for Studies

Building a sewer planning study for proposed and/or existing sewer facilities shall be prepared, as directed by the SNL/CA Project Lead. The planning study shall be performed by a Civil Engineer registered in the State of California.

3.9.2.2 Capacity

For a new development, the planning study shall address the capacity of all sewer collection and main sewer systems that will be impacted downstream of the new development and shall demonstrate that sewer capacity is available in those systems to accommodate the new development and/or redevelopment. Authorization and approval to impact any downstream sewer system must be obtained from the SNL/CA Project Lead. If such downstream sewer system has already been identified as critical in a monitoring report, the Engineer may require additional field monitoring of such downstream sewer systems to determine if adequate capacity is available.

Field studies may include both dry and wet weather flow monitoring for a period of one month. The Engineer shall complete a hydraulic model of the collection system for both dry and wet weather flows illustrating the hydraulic grade line. Wet weather flows shall be completed during the anticipated winter months between October and April.

For an existing development and/or new development, the planning study shall address the existing capacity within the existing sewer collection system, and identify all existing facilities whose capacity will be exceeded by projected sewage flows. Where available capacity will be exceeded, the planning study shall propose up-sizing of sewer facilities in accordance with this Chapter.

3.9.2.3 Depth of Mains

The planning study shall clearly identify all existing or proposed facilities, which will exceed standard depths for sewer mains as defined in Subsection 3.1.1.5. In cases where sewer depths are proposed to exceed 15 feet in depth, a request for design deviation must be submitted to the Engineer with the Sewer Planning Study. A design deviation will only be approved in exceptional cases and when adequate justification is provided.

3.9.2.4 Flow Estimation

3.9.2.4.1 Land Use

Present or future use, whichever results in the higher sewer demand, shall be used to generate potential sewage flows.

3.9.2.4.2 Flow Determination

The Project Engineer shall complete an estimate of the average dry weather flow (ADWF): generated by the project. If this information is not available, the design engineer can base the flow on the following:

Development	Average Daily Flow gpd/Unit	Unit
Office	200	1000 gross square feet
Residential Multi-Family	100	Dwelling unit
Food Service	300	1000 gross square feet
Child care	10	Child

The Engineer shall apply a peaking factor to the ADWF. The peaking factor is the ratio of peak dry weather flow to average dry weather flow. It is dependent upon the type of development proposed. While, the factors can range from 1.5 to 4.0, unless there is site-specific knowledge available, the Project Engineer shall use a value of 2.5.

Peak Dry Weather Flow = (Average Dry Weather Flow) x (Peaking Factor for Dry Weather)

Evaluation of storm and groundwater inflow and infiltration shall be based on actual wet weather flow monitoring. When this information is not available, the Engineer can use a value of 4,000 G/inch-diameter-mile per day. Thus, the flow used to evaluate the capacity of the system is:

Peak Wet Weather Flow (PWWF) = Peak Dry Weather Flow + inflow and infiltration

3.9.2.5 Sewer Piping

3.9.2.5.1 Materials

Acceptable sewer pipe materials include:

1. Polyvinyl Chloride (PVC) SDR 35 and SDR 26 conforming to ASTM D3034 for 4 to 15 inch in diameter
2. Polyvinyl Chloride (PVC) SDR 35 and SDR 26 conforming to ASTM F679 PS46 and PS115 for 18 to 36 inch in diameter
3. Ductile Iron Pipe (DIP), Class 52 with approved lining/coating

3.9.2.5.2 Minimum Pipe Sizes

The size of a sewer pipe is defined as the inside diameter of the pipe. Sewers shall be no less than the following sizes:

1. Mains – 12 inch in diameter
2. Collectors – 8 inch in diameter
3. Laterals – 4 inch in diameter

3.9.2.5.3 Hydraulic Requirements

Manning’s formula shall be used to calculate the capacity of gravity sewer mains. Manning's coefficient of roughness "n" shall be assumed to be 0.013 or the pipe manufacture’s value whichever is higher.

3.9.2.5.4 Pipeline Capacity

Main and collector sewers shall be designed on the following basis:

1. For sewers eight (8) and ten (10) inches in diameter, design capacity shall be based on pipes flowing no more than two-thirds full (d/D < or = 0.67).
2. For sewers twelve (12) inches and larger in diameter, design capacity shall be based on pipes flowing full without surcharging (d/D < or = 1.0).

3.9.2.5.5 Velocity and Slope

The minimum acceptable slope for sewer pipe is based upon a velocity of two (2) feet per second for main and collector sewers, when flowing full. The minimum and maximum design flows for each pipe size at the minimum acceptable slope in the following table.

Collector

Nominal Pipe Size In Inches	Minimum Design Flow (Cubic feet per second)	Maximum Design Flow (Cubic feet per second)	Minimum Slope In Feet Per Foot
8	0.0		0.0077
10	0.82		0.0057

Main

12	1.29	1.57	0.0022
15	1.58	2.45	0.0015
18	2.46	3.53	0.0012
21	3.54	4.81	0.00095
24	4.82	6.28	0.0008
27	6.29	7.95	0.0007

SNL/CA may allow a lesser slope and/or a larger pipe size on a case-by-case basis where the elevation of the existing system constrains the available elevation drop.

The flow velocity shall not exceed 10 feet per second.

When the slope of the sewer exceeds twenty percent (20%), ductile iron pipe shall be used.

3.9.3 Pump Station Planning Criteria

If at all possible, the use of sewer pump stations is to be avoided. However, in cases where constraints such as topography and environmentally sensitive habitat dictate, a pump station may be necessary.

3.9.3.1 Pump Station Design Capacity

The Pump Station Design Capacity shall be calculated as follows: Pump Station Design Capacity (PSDC): Pump stations shall be designed to pump the calculated peak flow from the source. Pump Station Reserve Capacity Factor (PSRCF): This is a safety factor that takes into account that service pumps will generally not be operating at their full intended design capacity due to mechanical wear and the subsequent loss of efficiency, and increases in force main friction loss due to the deposition of solids and grit. The reserve capacity factor shall be 1.0 if two (2) hours emergency storage or six hours emergency storage are provided. Where this storage is not provided in design, then a reserve capacity factor greater than 1.0 shall be used and an appropriate factor shall be evaluated for approval on a case-by-case basis by the Engineer overseeing the preparation of the planning study.

Pump Station Design Capacity = (Peak Wet Weather Flow) x (Pump Station Reserve Capacity Factor)

3.9.3.2 Pump Station Emergency Power

Pump stations serving collector sewers shall have emergency power served by a diesel or natural gas generator. The generator shall have a fuel tank providing at least 12 hours of service. Sewer pumps shall not be allowed on sewer mains.

3.9.3.3 Telemetry

Each pump station shall be equipped with flow sensors and alarms with wireless connections to SNL/CA facilities management.

3.9.4 Required Capacity in Existing Sewer Systems Downstream of New Facilities

3.9.4.1 Required Capacity Downstream of New Gravity Sewers

The Engineer shall verify the proposed new development impacts on the downstream sewer system. If existing wet weather flow data is unavailable, the Engineer shall complete wet weather flow monitoring for one month to establish:

1. Average dry weather flow
2. Peak dry weather flow
3. Peak wet weather flow

Using this data, the Engineer shall evaluate the effect of adding the project's new wastewater flows. The peak wet weather flow shall not exceed the pipeline capacity as defined in Chapter 2.1.2.5.4.

3.9.4.2 Required Capacity Downstream Pumping Stations

The Engineer shall complete a similar evaluation as described in Chapter 2.1.5.1. In addition, the system downstream of the pump station's discharge point shall be designed for the cyclical effect (i.e., on/off pumping). The cyclical effect of the pump station may be considered negligible when the discharge capacity of the pump station is less than 10% of the total flow conveyed in the pipeline based on actual measured conditions.

3.10 Gravity Sewer System Design

If the Engineer does not have experience with the soil present along the length of the new sewer main, he or she shall complete a geotechnical investigation to evaluate soil type, groundwater level, and general conditions.

3.10.1 Design of Sewer Mains

3.10.1.1 Determination of Allowable Loading

For PVC pipe, the Engineer shall complete a deflection analysis using the Modified Iowa Equation using potential loads as well as the stiffness of the pipe and backfill materials. This evaluation can be completed using various pipe manufacturers' data.

Depth of cover for ductile iron pipe is available from various manufactures' data.

3.10.1.2 Design Deflection in PVC Pipe

Allowable deflection shall not be in excess of the manufacturer's recommendations.

3.10.1.3 Traffic Loads, Dead Loads, and Other Loads

The Project Engineer shall pay special attention to the design of sewer pipes from the standpoint of traffic loads, dead loads, and other loads that the pipes may be subjected to during their design life. Pipes that fall within 100-year flood areas or below groundwater table shall be reviewed for hydrostatic up lift. Deflection of shallow mains with less than 4 feet of cover shall be minimized by special design as required by the Engineer, in order to avoid adverse effects on pavement sections.

3.10.1.4 Depth of Sewer Collectors and Mains

Minimum and maximum allowable cover for installation of main and collector sewers shall be 4 to 15 feet respectively. The Engineer shall consider the potential expansion of the sewer system when considering the minimum depth.

A soils report shall be required for pipes deeper than 15 feet. A geotechnical report and settlement calculations are required in such cases in order to account for any potential for differential settlement or other settlement that may detrimentally affect the pipe slope.

Where sewers are to be installed in existing roadways that are not expected to receive major grade or surfacing changes, the pipe cover may be measured from the existing road surface to the top of pipe. Where sewers are to be installed in new roadways and/or in areas expected to become roadway, or in

existing roadways that are intended to receive major grade or surfacing changes, the pipe cover shall be measured from the lower surface of the road structural section (bottom of the subbase) to the top of pipe.

No sewer work shall begin in new or existing roadways that are scheduled for major improvement, until the roadway has been graded to within six (6) inches of design subgrade elevation at the lower surface of the road structural section (bottom of the subbase).

Pipes placed on slopes that exceed 20% shall be ductile iron pipe.

No lateral connections will be allowed on mains that exceed 20 feet in depth. In those cases where mains are permitted to exceed 20 feet in depth, and lateral connections are necessary, a parallel collector sewer shall be required at standard depths.

The engineer shall select SDR 26 or SDR 35 pipe based on the depth of burial and the pipeline's allowable loading.

Dead-end mains with the potential for future extension shall not be less than 7 feet in depth at the dead-end, and shall not preclude any property in the upstream basin from obtaining sewer service. Deviations from such criteria shall require approval by the SNL/CA Project Lead. Grades shall be as uniform as practical.

3.10.2 Separation of Mains

3.10.2.1 Horizontal and Vertical Separation

The separation of water, sewer, and reclaimed water mains shall comply with the State of California Department of Health Services Criteria for the Separation of Water Mains and Sanitary Sewers (Appendix A).

3.10.2.2 Crossing Mains

The minimum vertical separation shall be 12 inches between the top and bottom surfaces of crossing utility conduits and shall comply with the *State of California Department of Health Services Criteria for the Separation of Water Mains and Sanitary Sewers* included in Appendix A.

Where the vertical separation is less than 12 inches but more than 4 inches to potable water lines, a 20-foot long segment of PVC SDR-26 pipe shall be centered on the water main.

3.10.2.3 Separation for Other Utility Pipes and Cable Conduits

Other utility pipes, conduits, and cable lines shall be governed by their respective SNL/CA design standards. A 10-foot horizontal separation is desirable between sewer mains and any other utility infrastructure. Separations of less than 10 feet must be approved by the SNL/CA Project Lead. Additional separation may be required for sewer mains which exceed 10 feet in depth. The Project Engineer shall consider the relative depth of adjacent utilities and the stability of the soils where the sewer shall be constructed when designing the separation from other utilities.

3.10.3 Alignment of Sewers

3.10.3.1 General

Sewers designed to serve facilities on both sides of a street shall be located along the centerline of the street.

If the sewer will serve the property on one side of a street only, it may be located on that side of the street if no potential conflict with other utilities exists. If there will be or could be a raised median, the sewer shall be located a minimum of 5 feet from the median curb, but shall be a minimum horizontal distance of 10 feet from any trees or shrubs that are 3 feet or higher at maturity.

Sewer mains shall be located clear from environmentally sensitive areas. The clearance from trees shall be as defined by an arborist.

Sewer mains shall not be placed in areas of erosion or where the area over the main will receive storm flows such as from a side canyon or storm drain outlet. The sewer main shall be maintained 10 feet from the edge of paving and 15 feet from structures where practical.

Where sewer lines will be located near existing buildings, the Engineer shall complete an analysis to verify the trenching will not be subject to additional loading. This may require specialized shoring or underpinning of the building to prevent settlement.

The minimum distance between the facing edges of proposed sewers and parallel existing utilities shall be at least 10 feet. Deviations, if allowed, shall be approved by the SNL/CA Project Lead.

3.10.3.2 Skew Utility Crossings

Long skew crossings under existing or proposed substructures and utilities shall be avoided. Sewers shall cross substructures and utilities as close to perpendicular as possible. Skew angles of less than 75 degrees shall be avoided and shall require a request for design deviation and approval by the SNL/CA Project Lead.

3.10.3.3 Changes in Direction

Sewer mains shall not have a change of horizontal direction greater than 90 degrees. Changes in direction can be accomplished by fittings or pipe joint deflection. For changes greater than 45 degrees or where not possible by joint deflection, they shall occur in manholes.

3.10.3.4 Curvatures

Curvature in pipe shall be avoided whenever possible. The design of pipe curvature shall be reviewed and approved by the SNL/CA Project Lead.

3.10.3.5 Anchor Walls

In unpaved areas with steep terrain, pipes and pipe bedding shall be protected by anchor walls. In paved areas with steep terrain, pipe shall be protected by concrete anchor walls per SNL/CA Standard Design Drawings.

In areas requiring anchor walls, a geotextile fabric shall be placed around the pipe bedding in order to prevent erosion of fine soil particles from the bedding material.

3.10.4 Manholes

3.10.4.1 General Design Considerations

All manholes shall be constructed in accordance with SNL/CA Drawings. The Plans shall show invert elevations within the manhole of both the inlet and outlet pipes and the rim elevation of each manhole. Drop manholes are not allowed for connections where Hydrogen Sulfide may be present and are to be used only where changes in elevation preclude the use of other methods of connection.

3.10.4.2 Manholes

All sewer manholes outside a pave street shall have adequate vehicular access for sewer maintenance vehicles per Chapters 3.2. All manholes located outside of the public right-of-way shall be equipped with approved tamper proof covers with collars as indicated on SNL/CA Standard Drawings, or as specified by the SNL/CA Project Lead. Special details may be required based on operation and maintenance requirements.

3.10.4.3 Required Locations

Manholes shall be required at all of the following locations:

a. Change of grade
b. Changes in pipe size
c. At the intersection of mains
d. At the terminus of dead-end sewers
e. When pipe material changes**.**
f. Change of flow direction
g. At the discharge of a pump station force main, the Project Engineer shall provide a dedicated manhole prior to discharge to the gravity system
h. No more than 400 feet from manhole to manhole

3.10.4.4 Manholes at Street Intersections

Where a new or reconstructed sewer main passes through a manhole in a street intersection and the manhole has no side inlet or future planned connecting main, the manhole shall be located approximately 30 feet either downstream or upstream of the intersection. This manhole location will afford improved maintenance access and easier traffic control for construction/cleaning crews in high traffic streets.

3.10.4.5 Prohibited Locations

Manholes shall not be placed in the following locations:

a. Inaccessible areas
b. Gutters and other depressions or areas subject to inundation

c. In sidewalks, crosswalks, or pedestrian ramps
d. In driveways
e. Within 15 feet of any structures, including subterranean or overhead structures.
f. Within any area subject to flooding or inundation during a 100-year storm event.

3.10.4.6 Potential Hydraulic Jumps

Where the change in grade of the inlet and outlet pipes is greater than 10 percent, or the potential for a hydraulic jump within a manhole exists, the grade change shall be made in a smooth vertical curve, upstream of the manhole, with the manhole located 25 feet downstream of the lower end of the vertical curve.

3.10.4.7 Dead-End Sewers

Dead-end sewers, for which no immediate future extension is planned or anticipated, shall require manholes for cleaning and televising for maintenance assessment. Refer to Subsection 3.1.1 for requirements regarding dead-end sewers.

3.10.4.8 Manhole Frames and Covers

Manhole frames and covers shall be non-rocking and shall conform to the requirements of ASTM A48, Class 30. Unless otherwise indicated, manhole frames and covers shall be heavy-duty cast-iron type with a 36-inch opening. Manhole cover inserts shall be 24- inch diameter with lettering “SEWER".

3.10.4.9 Manhole Lining and Grouting

3.10.4.9.1 Bases

The manhole base shall be primed with epoxy and lined with a 100-mil dry film thickness (DFT) of 100 percent solids elastomeric polyurethane with a minimum, Shore D, hardness of 55 in accordance with *SSPWC Section 500- 2.4 B Air-Placed Concrete and Polyurethane Protective Lining Manhole Rehabilitation*, or other methods and materials included in the SNL/CAs Approved Materials List for municipal sewer applications. The lining shall be continuous, without seams, and free from any defects, holes, or surface irregularities. The CONTRACTOR shall furnish a minimum of two plugs per manhole to permit verification of the applied thickness.

3.10.4.9.2 Riser Joints

Polymer mortar shall be used for riser joints on manholes to create water-tight joints to resist or minimize infiltration.

3.10.4.9.3 Risers

Manhole risers in the wastewater collection system shall be epoxy grouted and lined with PVC, (or T-Lock, or other methods and materials included in the SNL/CA’s Approved Materials List for municipal sewer applications) in the following cases: (See Drawing for typical application.)

a. Manholes for all trunk sewers.

b. At locations of force main discharge
c. Manholes where high concentrations of hydrogen sulfide exist, (e.g. d. sealed manholes, manholes in areas downstream of sewer pump stations, and manholes upstream from siphons)
d. Manholes where groundwater is present

3.10.4.9.4 Exterior Walls

Waterproofing of exterior walls of manholes with a coal tar emulsion (water proofing agent) shall be required for all manholes in environmentally sensitive areas, or below the water table. The coal tar emulsion shall be applied in no less than two coats for a total dry film thickness of 25 to 35 mils.

3.10.4.9.5 Minimum Invert Drop Across Manholes

The invert drop required across manholes and transition structures shall be calculated to provide smooth laminar flow through the manhole and shall not be arbitrarily established.

3.10.4.10 All Pipes the Same Diameter

a. Straight-Through Flow for Small Diameter Mains or Trunk Sewers with Velocity = 2 fps: For all sewers 12 inches in diameter and smaller where the peak design velocity is 3 fps or greater, the slope of the pipe shall be carried through the manhole.
b. Side Inlet for All Pipe Sizes: The invert drop across the manhole shall be the inside diameter (D) of the manhole in feet multiplied by the average slope of the side inlet (s1) and outlet (s2) sewers, plus 0.10 feet of additional drop. However, a minimum invert drop of 0.20 feet shall be required.

Invert drop= (D*(s1+s2)/2)+0.1 greater than 0.2

3.10.4.11 Outlet Pipe Larger Than Inlet

When the outlet pipe is larger than the inlet pipe, the same calculations as shown above in Chapter 2.3 shall be used, and the drop shown in Table 3-1 shall be added to the result of each calculation. Table 3-1 is based on matched water surface profile from the upstream pipe to the downstream pipe, when flowing ½ full. The Table may be used in lieu of calculating invert drops across a manhole due to the change in pipe diameters. However, if the sewer main is in an area where the slopes are flat, individual invert drops may be calculated based on the planning study design dn/D at peak flow.

Table 3-1 Invert Drops Across Manholes

Dia. Of outlet	Dia. Of Inlet in Inches (drop to be added in Feet)		
Inches	8”	10”	12”
10”	0.08	Banned	Banned
12”	0.17	0.08	Banned

Outlet pipes smaller in diameter than the inlet pipe shall not be allowed. In lieu of calculating the drop through a manhole, where there are good slopes and proper manhole channelization, the crown of the pipes may be matched.

3.10.4.12 Maximum Invert Drops Across Manholes

Maximum invert drops across manholes for sewers 10 inches and smaller in diameter shall be 0.60 feet for straight-through flow, and 1.00 feet for side inlet flow.

3.10.4.13 Minimum Manhole Size

The minimum manhole diameter shall be 4 feet per SNL/CA, but not less than the pipe diameter plus 3 feet.

3.10.4.14 Deep Manholes

For sewer mains that exceed 25 feet in depth, vaults shall be provided with a minimum of two access manholes for each vault. Calculations shall be provided to show that the vault structures are designed to accommodate the design depths. A separate structural permit is required.

3.10.4.15 Inspection of Exiting Manholes

Removal of existing SNL/CA manhole covers is not permitted by unauthorized personnel as potentially lethal, poisonous gases may be present. If access to any existing SNL/CA manhole is necessary for design purposes, please contact the SNL/CA Project Lead.

3.10.5 Pipe Bedding

3.10.5.1 Normal Bedding Requirements

Normal bedding is full rock encasement. All sewers, including laterals with normal cover, shall be adequately bedded according to SNL/CA Standard Drawings. The induced trench method of construction in which the trench is excavated in compacted fill and refilled with loose compressible materials shall not be allowed.

3.10.5.2 Special Considerations

Where the possibility exists for erosion, migration, separation, or segregation of sands and silts from the trench wall into the pipe bedding, or where the sewer pipe is installed below the water table, the rock envelope shall be wrapped with an engineering geotextile fabric.

3.10.6 Sewer Laterals

3.10.6.1 Allowable Locations

Every new building shall have at least one sewer lateral. All new sewer laterals shall not be located in driveways or other vehicle paths of travel unless no other alternative exists. If the laterals already exist, or sufficient area is not available to locate the lateral(s) outside of driveways due to cul-de-sacs, trees etc., the installation shall be according to SNL/CA Standard Drawings which shall be included on the improvement plans. Laterals shall not be located within 5 feet of water meters or within10 feet of trees or shrubs that are 3 feet or higher at maturity. Sewer laterals shall be a minimum of 5 feet apart (center to center).

3.10.6.2 Backwater Devices

Sewer laterals shall be equipped with an approved backwater device at all locations where dictated by the currently adopted edition of the Uniform Plumbing Code to prevent public sewage from spilling into structures if the sewer main should fail. Backwater devices shall be installed outside of the public right-of-way and shall be maintained by the property owner.

3.10.6.3 Pressure Laterals

A pressure lateral is a pipe under pressure carrying a discharge from a property sewage pump. Pressure laterals shall not be smaller than 2 inches in diameter. If there is a cleanout at the property line with a gravity lateral to the main, it will not be construed to be a pressure lateral. Pressure laterals shall discharge into a manhole which shall be lined with PVC (i.e., T-lock), or other approved methods and materials. All manholes into which pressure laterals discharge shall be clearly labeled as such on the sewer plans. All pressure laterals shall be shown on the sewer plans; shall be equipped with a check valve; and shall require an EMRA. When a pressure lateral terminates at the discharge manhole, with a clean out, and becomes a gravity lateral, then the gravity lateral portion should comply with gravity lateral requirements.

3.10.6.4 Depth Requirements

Sewer laterals shall be between 3 feet and 5 feet in depth. When special circumstances dictate that the cover over a lateral must be less than 3 feet, the lateral should be fully encased in concrete see SNL/CA Drawing No. 10021, loading and deflection calculations must be submitted, and approval by the Engineer shall be required. Polyvinyl chloride (PVC) shall not be used with concrete encasement. Use only extra strength vitrified clay pipe or ductile iron pipe with concrete encasement. Lateral connections to deep sewers (depth >15 feet) shall be avoided wherever possible. No lateral connections will be allowed on mains which exceed 20 feet in depth.

3.10.6.5 Cleanouts

All laterals shall have a cleanout. The cleanout shall be installed in accordance with SNL/CA Drawings No. 10016. If there is a sidewalk located at the building line, the cleanout shall be located within the sidewalk .Where a future building will be located along a new main, the depth of the main shall be coordinated with other utilities so that there will be no conflicts with the future sewer lateral.

3.10.6.6 Slope

Minimum lateral slopes shall be 2% for a 4-inch line, 1%, for a 6-inch line, and 0.5% for an 8-inch line.

3.10.6.7 Bedding

Sewer laterals shall be bedded in accordance with SNL/CA standard specifications and SNL/CA Drawing No. 10020.

3.10.6.8 Main Replacements

When a sewer main is being replaced or relocated, the existing laterals running to it, but not being used shall not be replaced or reconnected.

3.10.6.9 Connection to Existing Mains

3.10.6.10 Required Locations of Connections

Sewer lateral connections shall be made in accordance with Table 3-2:

Table 3-2 Sewer Lateral Connections

Size/Type of Lateral	Size of Main	Connection Made At
Note: at no time shall the main be smaller than the lateral		
6" or smaller	10" or smaller	Manhole
10" or larger	Any Size	Manhole
Pressure Lateral	Any Size	Manhole

3.10.6.11 Allowable Types of Connections

Lateral connections to existing sewer lines may only be made through a “Y” fitting or saddle type connection. Cutting or breaking out an opening for lateral connection and sealing the opening with a concrete lug shall not be allowed.

3.10.6.12 Size of Connections

Connections of sewer laterals into existing sewer mains shall be at least 2 inches less than the diameter of the sewer mains into which they discharge. However, 6-inch and 8- inch diameter laterals may connect into a sewer main of the same size provided that the connection is made through a “Y” fitting. The "Y" branch of the sewer main is to be inclined upward at a maximum angle of 45 degrees from the horizontal and connected to the lateral through a 1/8 bend.

3.10.6.13 Required Rise of Main

The vertical distance between the invert of the sewer main at the "Y" location and the invert of the upper end of the 1/8 bend is termed the "rise". Minimum values for the rise versus various sewer main sizes are given in Table 3-3.

Table 3-3 Minimum Values of Rise From Sewer Mains

Sewer Main Size (inches)	Minimum Rise (Feet)
8	1.2
10	1.3

For determining the slope of the sewer lateral, it may be assumed that the 1/8 bend terminates 2.0 feet laterally from the center of an 8 inch diameter sewer main.

3.10.7 Wastewater Improvement Plans – Standards

Plans of all sewer facilities shall be routed by the SNL/CA Project Lead.

3.10.7.1 Improvement Plan Requirements

All improvement plans shall be prepared in accordance with this *Sewer Design Guide* using standard SNL/CA drawing format.

3.10.7.2 Pipelines

Improvement plans for pipelines shall include the following minimum information:

a. Title sheet(s): Location and vicinity maps; project title; legal description of the property; list of utility phone numbers; phone number for underground service alert; list of referenced improvement drawings; standard drawings; standard specifications; list of abbreviations; legend; work to be done; standard notes; engineer of work; statement of responsible charge; north arrow(s).
b. Plan and profile sheet(s): Scale; north arrow(s); screened profile grid; basis of bearings (if applicable); benchmark information; project title; existing and proposed contours over pipe; all existing or proposed utilities that may run parallel with or cross the new pipe (i.e. storm drain, potable water, pressurized irrigation, lighting and electrical, etc.); diameter of pipe; pipe material; concrete encasements; stream crossings, plan and profile of the proposed pipe(s).
    1) Plan strip: Location of proposed pipe with horizontal ties to building and right-of-way boundaries or known and established physical improvements; all horizontal alignment information including stationing, horizontal curve data, location and description of structures.
    2) Profile strip: Depth of cover; pipeline slopes; stationing; offset (if applicable); bridge abutment locations and culvert crossings. For main sewers, show both the calculated peak dry weather flow and approved peak wet weather flow used in the design of the sewer as well as the calculated hydraulic grade line.
c. Details: Special and complicated structures if not included in the Standard Drawings; complex utility crossings; special manhole(s); special trenches; sewer access road sections, etc.

3.10.7.3 Special Facilities

Improvement plans for special facilities such as pump stations and metering stations shall include the following information:

a. Title sheet(s): Location and vicinity maps, project title, legal description of the property, list of utility phone numbers, phone number for underground service alert, list of referenced improvement drawings, standard drawings, standard specifications, list of abbreviations, legend, standard notes, engineer of work, north arrows on all maps and plan views.
b. Site grading plans : Scale, north arrow, basis of bearings, benchmark information, existing and proposed contours, existing and proposed surface and subsurface drainage facilities, soils report (if required), finished elevations for proposed improvements. Legal descriptions shall accompany the plans.

c. Paving plans: Access, on-site vehicle parking, turnabout areas, proposed curbs, berms, gutters, walkways, wheel stops, and pavement striping, typical pavement sections.
d. Utility plans: Existing and proposed facilities for all on-site utilities (electricity, telephone, alarm, cable TV, water, sewer, storm drain, irrigation, gas, chilled water, steam, etc.)
e. Other plans: Irrigation and landscaping, structural, plumbing, mechanical, architectural, electrical, and instrumentation for special facilities.

3.10.7.4 Notes on Improvement Plans

The following notes shall be shown on the plans, as applicable:

1. Each building shall receive a sewer building connection, based on the current California State Plumbing Code unless otherwise indicated on the plans or special specifications. Location shall be determined in the field by the engineer of work. The "As-Built" locations shall be shown on these plans and the sewer lateral table completed prior to acceptance of the sewer facilities.
2. Sewer building connections shall be located out of driveways and a minimum of ten feet from trees. The sewer building connections shall be a minimum of 5 feet down-gradient from the water service.
3. All valves for sewer force mains shall be flanged to crosses and tees.
4. All buried ductile iron pipes, fittings, valves, and appurtenances shall be coated with a liquid epoxy coating system per AWWA C-210 at 24-mil minimum dry film thickness (DFT). Also prior to backfilling, all fittings shall be coated with a cold-applied three-part system petroleum wax tape, Trenton Inc., or equal, in accordance with AWWA C-217, or a polyurethane coating of 24 mils DFT with, Shore D, hardness of 55 for buried use.
5. Shop Drawing Submittals: Prior to fabrication, shop drawings shall be prepared and submitted to the Project Engineer for review and approval. The Project Engineer shall certify that the shop drawings meet the intent of the signed design plans and specifications. The approved shop drawings shall then be submitted to the Project Engineer per SNL/CA Standard Specification 013300, Submittal Procedures.. Once the shop drawings have been accepted by the Engineer, the materials may be manufactured at the plant.
6. All horizontal separation dimensions shown between water and sewer mains shall be measured from the nearest surface of each pipeline per State of California Department of Health Services, Basic Separation Standards.
7. No trees shall be allowed within 10 feet of any sewer main or lateral.
8. Prior to connecting to any existing sewer lateral, the lateral shall be inspected using a closed-circuit television (CCTV) by a California Licensed Plumbing Contractor to verify the lateral is in good working condition and free of all debris.
9. For all Sewer Plans: The Contractor shall observe and comply with all federal, state, and local laws, ordinances, codes, orders, and regulations which in any manner affect the conduct of the work, specifically as it relates to sewage spills. The Contractor shall be fully responsible for preventing sewage spills, for containing sewage spills, and for recovery and legal disposal of any spilled sewage, and for any fines, penalties, claims and liability arising from causing a sewage spill, and for any violation of any law, ordinance, code, order, or regulation as a result of the spill(s).
10. For Work Involving Connection to Existing Facilities: Prior to the start of construction which involves any existing wastewater facilities, the Contractor shall be responsible for developing and submitting to the Engineer for review and approval, a Wastewater

Flow Diversion Plan in compliance with the SNL/CA's Policy of "ZERO SPILLS" at least fifteen working days prior to implementation of the plan and in accordance with SNLCA Standard Specifications Division 01,"General Requirements." The diversion plan shall include an emergency response plan indicating the procedures, equipment, and activities that will be implemented in the event of an emergency shutdown or failure of the flow diversion equipment used for construction The Contractor shall be responsible for implementation of the emergency plan.

11. For Work Where Bypass Pumping May Be Involved: Prior to the implementation of any flow diversion, the Contractor shall be responsible for developing and submitting to the Engineer, for review and approval, a Wastewater Flow Diversion Plan. The Contractor's Wastewater Flow Diversion Plan shall be reviewed and approved by the Projects Office, before any flow can be diverted. The Diversion Plan shall indicate the sequence of diversion operations and all other operations the Contactor will establish to maintain wastewater service during the construction period. The Diversion Plan shall include a comprehensive emergency response plan, including standby redundant by-pass equipment, in the event of an emergency shutdown or failure of the flow diversion equipment. The Contractor shall be responsible for implementation of the emergency plan in accordance with SNL/CA Standard Specifications.

3.10.7.5 Legend Items

The following legend items and corresponding standard drawings shall be shown on the plans, as applicable:

a. Size (INCHES),Type (MATERIAL), and Rating (CLASS) of Sewer Main:
b. Sewer Manhole: For 15" dia. mains and smaller, PVC lined.
c. Sewer Lateral (4" PVC) with Cleanout: SDS-100, S-13, S-19, S-4C,
d. Concrete Encasement: SNL/CA Drawing No. 10021, S-7 (ESVC or Lined and Coated Ductile Iron). Note: Use of Ductile Iron requires a full review and approval by the Corrosion Engineer.
e. Anchor Wall : SNL/CA Drawing No. 10023
f. Sewer Lateral Cleanout: SNL/CA Drawing No.(s) 10016 and 100

3.10.7.6 Data Tables

Tables 3-4, 3-5, and 3-6 shall be shown on the plans and completed, as applicable.

3.10.7.7 Sewer Main Abandonment

Table 3-4 Sewer Main Abandonment

SYMBOL	SIZE	TYPE	LENGTH	YEAR INSTALLED

3.10.7.8 Sewer Data Table

Table 3-5 Sewer Data Table

No	Bearing Delta	RADIUS	LENGTH	NOTES

Note 1: Allowable Minimum Radius of Curvatures (Longitudinal Bending for Flexible Pipe, PVC) is 8" = 200', 10" = 250', 12" = 300', and 15" = 350'.

3.10.7.9 Sewer Lateral Table

Table 3-6 Sewer Lateral Table

BLDG	I.E. at MAIN	DROP TO MAIN	LENGTH IN FEET	I.E. AT FENCE	SLOPE %	DEPTH BELOW CURB	STA. #	CLEANOUT LOCATION	REMAKS

Note 1: Show Drop to Main for all laterals; 1.2' for 8" mains, 1.3' for 10", 1.4' for 12", 1.8' for15".

Note 2: Minimum Slope is 2% for all laterals.

Legend:

E. = Invert Elevation P. L. = Property Line T. C. = Top of Curb

3.11 Abandonment of Existing Sewer Mains and Manholes

This Chapter addresses the requirements for abandonment of existing sewer facilities. Abandonment of any existing sewer facilities, including stubs or dead-end mains, requires the approval of the Engineer.

3.11.1 Abandonment of Sewer Facilities

All sewer mains and collectors greater than 8 inches in diameter designated to be abandoned shall be completely removed. Alternatively, the pipe shall be filled with sand or grout. This work includes either removing manholes or filling with sand. When filling a manhole, it shall be broken down to at least 48 inches below grade.

All sewer facilities to be abandoned shall be clearly shown on an approved set plans and clearly labeled as To Be Abandoned. On each sheet of the plans whereon sewer facilities are to be abandoned, Table 3-7 shall be shown on the plans and completed.

Table 3-7 Sewer Main Abandonment

SYMBOL	SIZE	TYPE	LENGTH	YEAR INSTALLED

3.12 Corrosion Control

The purpose of this Chapter is to provide general recommendations for corrosion control. General recommendations for material selection and protective coatings/linings are briefly summarized in Tables 3-8, 3-9, and 3-10 for sewer facilities. More specific recommendations for sewer applications are included in Tables 3-11 and 3-12. These guidelines are intended to be used by the Project Engineer in conjunction with the complete version of the Clean Water Program Corrosion Control Guidelines, Volume I, Section 9, and accepted industry standards and represent a minimum requirement for each circumstance presented. Where field conditions differ from those presented, the Project Engineer shall evaluate those conditions and make corrosion control recommendations.

All corrosion control drawings, designs and calculations shall be prepared and signed by a licensed California Corrosion Control Engineer or a certified, NACE International Cathodic Protection Specialist.

3.12.1 Material Selection and Considerations

A variety of options are available for eliminating or minimizing possible problems arising from corrosive environments. Selection of appropriate materials for a given service is the most important consideration. It is also possible, in some cases, to modify the environment to which the materials will be exposed. The use of coatings or linings can also be effective in controlling corrosion of materials exposed to corrosive environments. Electrochemical methods such as cathodic protection are also among the alternatives available to the Project Engineer for the work. It is also important to provide for monitoring of corrosion activity, where metallic materials are to be used in a corrosive environment. The following Chapters summarize information on the selection and performance of various materials to be used for sewer facilities. Supplemental information is provided in Tables 3-8, 3-9, and 3-10 and in Chapters 3.12.4, Cathodic Protection, and 3.12.6, "Coating and Lining", of this Chapter.

3.12.1.1 Ductile Iron

Ductile Iron pipe must be coated with a bonded coating where soil or groundwater resistivity is less than 10,000 ohm-cm. Cathodic protection should be considered in soils and liquids with resistivity between 5,000 and 10,000 ohm-cm, and is required where resistivity is less than 5,000 ohm-cm. Depending on the specific project, lining may also be required. All buried ductile and gray cast iron pipe, fittings, valves and appurtenances shall be coated with a dielectric coating: a liquid epoxy coating system per AWWA C-210 at 24 mils Minimum Dry Film Thickness (MDFT), or a cold applied three part system petrolatum wax tape per AWWA C217, or a 100% polyurethane coating of 24 mils MDFT suitable for buried use.

3.12.1.2 Ductile Iron Pipe 3 Inches and Greater in Diameter

Lining shall be fusion bonded epoxy, fusion bonded polyethylene, or polyurethane. Coating shall be coal tar enamel, fusion bonded epoxy, or polyurethane. Linings and coatings shall be compatible with each other.

3.12.1.3 Polyvinyl Chloride

Polyvinyl Chloride (PVC) is suitable for use in buried, submerged and atmospheric exposures. It should not, however, be used in contact with ketones, esters, aldehydes, and certain other organics commonly found in leaking underground fuel storage facilities and abandoned chemical storage sites. Soil tests should be conducted prior to the use of PVC piping in known or suspected areas of contamination. Its use should be limited to temperatures less than 140 F. PVC must be protected from ultraviolet radiation exposure by the use of an appropriate coating system as recommended by the manufacturer.

Table 3-8 Material Selection Guide

EXPOSURE						
material	Soil		Fluid		Atmospheric	
	C	**NC**	**C**	**NC**	**C**	**NC**
Ductile Iron	1	2	1	2	3	3
PVC	S	S	S	S	4	4
Other Polymeric Materials	S	S	S	S	4	4

(a) See Manufacturer's recommendation for specific requirements. Legend:
1 = Coated and/or Lined & CP
2 = Coated Only (See Coating Chapter & Corrosion Monitoring)
3 = Coated Only
4 = Must Provide Ultraviolet Protection
S = Suitable As Is
C = Corrosive
NR = Not Recommended for Service
NC = Non-Corrosive
CP = Cathodic Protection

Table 3-9 Coating Selection Guide

Exposure			
Material	Soil	Fluid	Atmosphere
Ductile Iron	FBE PWT CTE	E FBE	URE E L
PVC & Other Polymeric Materials	CNR	CNR	URE(UV Protection Outside Exposure)

Legend:
CTE = Coal Tar Epoxy (100% solids)
E = Epoxy High Solids (100%) (Interior Exposure) URE = Aliphatic Urethane (Exterior)
L = Latex (Acrylic) (Interior Exposure)
CNR = Coating Not Required
PWT = Petrolatum Wax Tape & Filler Paste
FBE = Fusion Bonded Epoxy

Table 3-10 Lining Selection Guide

Material	Exposure to Sewer
Ductile Iron	FBE
PVC and other Polymeric Materials	LNR

Legend:
LNR = Lining Not Required
FBE = Fusion Bonded Epoxy
PVC = Polyvinyl Chloride (T-Lock)

3.12.2 Pre-Design Surveys

3.12.2.1 Pre-Design Investigations

Investigation during pre-design surveys of ferrous pipelines requires determination of the location of other structures, with respect to the proposed facility, and whether the structures are cathodically protected. In addition, the operating parameters of the cathodic protection system(s) and resulting stray currents from adjacent facilities and pipelines need to be determined. This information should be considered in the design of cathodic protection systems, coating selection and corrosion monitoring systems for the proposed facilities.

Test stations should be installed near the location of possible interference between the existing and proposed structure(s). After the installation has been completed, half cell potential data should be collected for both the existing and the proposed structures with the cathodic protection systems operating and not operating. This testing should be coordinated with other utility agencies that may have cathodic protection equipment in the area. If the cathodic protection systems of other facilities cause the potential

of the structure(s) to be changed by more than 50 millivolts in either a positive or negative direction, then additional testing should be performed and consideration given to mitigation measures.

Corrosion mitigation measures could include reduction of current of the cathodic protection system(s) of the facilities, current drain stations, and the use of resistance bonds or other current control measures. For ferrous pipeline projects, resistivity measurements should be made at a maximum of 1,000-foot intervals along the proposed alignment and pipeline invert depth. At a proposed pump station site, measurements should be made in a grid pattern at distances which will provide representative data, but not exceeding 1,000 feet in either direction, and again at the design invert depth of the proposed pipelines.

Soil samples should be obtained at representative locations and at locations of low soil resistivity (less than 10,000 ohm-cm) for chemical analysis and laboratory resistivity testing. Where design or modification work is to be performed at existing facilities, half- cell potential surveys should be performed and, where cathodic protection is to be employed, current requirement testing should also be performed.

3.12.2.2 Stray Currents

Stray current surveys shall be performed on all metallic pipelines and appurtenances to locate power lines and other existing cathodic protection systems that may have an impact on the corrosion protection design of the project pipeline.

3.12.3 Corrosion Monitoring

Electrical continuity by bonding of all non-welded joints is required for all metallic or reinforced cylinder pipes for corrosion monitoring and cathodic protection. Joint bonding is no t required for welded steel pipe because this type of pipe is electrically continuous by the nature of its construction. Test stations are required at a maximum of 1,000-foot spacing intervals for all pipes, and at sewer pump stations, as warranted, so that corrosion can be monitored. Testing to be performed must include half-cell potential measurements for all pipe and facilities to be monitored. Testing is also required for cathodically protected structures.

3.12.4 Cathodic Protection

Design of cathodic protection systems B impressed current and galvanic (sacrificial anodes) B is dependent upon the specific structural and environmental considerations of each project and should be performed by qualified individuals. Design life of systems is typically 20 to 25 years or may be required to be equivalent to the design life of the structure. For either type of installation, monitoring of the installed system is essential to ensure continued proper operation of the system, throughout its life. Monitoring locations shall be selected to provide a level of confidence that the entire structure is being adequately protected and that the sites are accessible for future data collection.

3.12.5 Corrosion Control Testing

Corrosion control testing is an important aspect with respect to minimizing the adverse effects of corrosion at water and sewer facilities. Because the corrosion mechanism is most significantly affected by the environment in which the structure is located, it is important that the designer be aware of the anticipated conditions under which the structure will be required to perform. Gathering appropriate and reliable information about the environment will allow determinations to be made as to the corrosive

nature of the environment and which materials or corrosion control technique will be most effective and economical.

3.12.5.1 Soil Resistivity Testing

In attempting to predict corrosion problems associated with a particular type of pipe, for example, prior to installation, it is necessary to investigate the soil conditions along the pipeline route. Since corrosion of metal is an electrochemical process which, by definition, is accompanied by electric current flow, the electrochemical characteristics of a soil are of primary importance when evaluating corrosivity. Table 3-11 correlates soil resistivity in ohms-cm with degree of corrosivity.

Table 3-11 Resistivity Values - Corrosivity

Soil Resistivity ohms-cm	Degree of Corrosivity
0 - 1,000	Very Corrosive
1,000 - 2,000	Corrosive
2,000 - 5,000	Fairly Corrosive
5,000 - 10,000	Mildly Corrosive
Above 10,000	Negligible

Chemical constituents may also affect the performance of many materials and may often dictate not only the material to be used, but whether or not additional corrosion protection is warranted. For example, high sulfate concentrations would require the use of Type V cement or the substitution of concrete materials. High chloride concentrations generally indicate the need for a protective coating on metallic surfaces and may lead to recommendations for cathodic protection. Table 3-12 correlates the effect of chlorides or sulfates on the corrosion of steel or concrete.

Table 3-12 Corrosive Effect of Chlorides or Sulfates on Steel or Concrete

Degree of Corrosivity	Chloride Concentration (ppm)	Sulfate Corrosivity (ppm)
Threshold	300	1,000
Positive	300 - 1,500	1,000 - 2,000
Severe	Over 1,500	Over 2,000

3.12.5.2 Continuity Testing

The specific objectives of the electrical tests vary, depending on the test. However, they are required for corrosion monitoring and design of cathodic protection systems. Even if the proposed facility will not have a cathodic protection system, it may be adversely affected by foreign pipelines which have cathodic protection. Testing to ensure that there are no adverse impacts must be completed after construction of the proposed facilities.

3.12.6 Coating and Lining

In selecting materials for use in a sewer environment, two main factors must be considered. The materials must be capable of performing the desired function in a safe and economical manner. Also, the materials must operate satisfactorily over the design life of the facility. As corrosion-caused deterioration of materials is a likely mode of failure, it is important to select materials which are capable of withstanding the aggressive environment to which they are exposed. Coatings and linings used for sewer facilities must be resistant to moisture including possible splash zone exposure (intermittent exposure to air and moisture), atmospheric sulfides, sunlight, and atmospheric chlorides.

The Project Engineer must properly specify manufacturer's recommendations regarding surface preparation prior to coating or lining application. A quality coating is of little benefit if it does not adhere to the surface to be protected. See Tables 3-13 and 3-14 for a summary guide of coatings and linings.

3.12.7 Pump Stations and Force Mains

3.12.7.1 Pump Station Piping Coatings

All coatings for sewer pump station piping shall be applied in accordance with the manufacturer's recommendations to ensure the following: proper preparation of surfaces to be coated typically requires SSPC-SP-10 sand blast to "white metal", proper prime coat, recommended coating thickness per coat, required drying times between coats, and required air temperatures and humidity limits. Provide at least two coats to achieve required final dry coating thickness. Coatings shall be applied pinhole free. Table 3-13 summarizes the allowable coatings for pump station applications.

Table 3-13 Acceptable Coatings/Linings for Sewer Pump Station Piping

Lining and Coating Material	Acceptable Applications				Notes"
	Wet Well Applications		Dry Well piping		
	Interior Lining	Exterior Coating	Interior Lining	Exterior Coating	
Fusion Bonded Epoxy	X	X	X	X	
High Density Epoxy (100% solids)	X	X	X	X	a,b
Polyethylene	X	B	X	B	B
Polyurethane	B	X	B	B	B
Enamel	B	B	B	B	B

Notes:
a. Minimum dry thickness of coating is 12 mils, applied pin-hole free in two coats. b. Only allowable for fittings/valves where fusion-bonded epoxy cannot be used.

Force Main Linings and Coatings
Allowable corrosion protective coatings and linings are given in Table 3-14.

Table 3-14 Force Main Corrosion Protective Coatings and Linings

Lining and Coating Material	Force Main Interior Piping	Force Main Exterior Piping	Comments
Fusion Bonded Epoxy	X	X	b
High Density Epoxy (100% Solids)	X	X	a,b,c
Fusion Polyethylene	X	B	b
Coal Tar Epoxy	B	X	b,d
Wax Tape Wrap	B	X	b

Comments:
a. Epoxy 12 mil minimum dry film thicknesses.
b. Factory applied coatings and wax tape wraps all buried ferrous pipes and fittings.
c. Allowable for fittings/valves where fusion-bonded epoxy cannot be used. d. Coal tar 20 mils minimum dry film thickness.

3.12.7.2 Valve Coatings

All valves located in the dry well, wet well, or in buried service shall be coated with fusion-bonded epoxy coating (3M "Scotchkote" #134 or equivalent) inside and out with a 12 mil. minimum thickness. Where fusion-bonded epoxy cannot be applied, high-density liquid epoxy (3M, Inc. #312 or equivalent) shall be allowed (note in project specifications).

3.12.7.3 Pump Interior Lining

Coat the pump bowl and casing, inside and out, and the suction can interiors with 3M Inc. #134 "Scotchkote" fusion-bonded epoxy or approved equivalent. Final dry coating thickness shall be a minimum of 8 mils.

3.12.7.4 Wet Well Walls

The interior ceiling and walls of wet wells shall have cast- in-place T-Lock PVC liner. Wet well floors shall be coated with 100 mils of polyurethane over an epoxy primer base in accordance with SSPWC, Section 500-2.4.

USE PDF Attachment State of California

GUIDANCE MEMO NO. 2003-02: GUIDANCE CRITERIA FOR THE SEPARATION OF WATER MAINS AND NON-POTABLE PIPELINES
Dated October 16, 2003

4.0 Landscape Design

These design standards generally apply to the Landscape Design phase on all projects. For general requirements that apply to all project phases, see Chapter 2.0, General Design Standards and Procedures. For specific project requirements, refer to the design criteria. For standard product specifications, see the applicable sections in the Sandia National Laboratories, California (SNL/CA) Standard Specifications. The design criteria take precedence over this chapter of the *Design Standards Manual*.

4.1 Purpose

This chapter defines how to design and develop landscape requirements for the SNL/CA campus. The design must promote efficient water use through landscape design and irrigation concepts appropriate to Livermore's climate zone (USDA Hardiness Zone 9a and Sunset Zone 14).

4.2 Landscape Construction Drawings and Specifications

Landscape drawings for construction must include quantitative information. Such information must be described in the project specifications and not be duplicated in the drawings, except as needed in the irrigation schedule.

4.3 Landscape Construction Drawings

See Chapter 2.0, General Design Standards and Procedures, for information on drawing organization and the arrangement of the overall Construction Drawing Set. Accurately prepare the drawings to scale with the various plans to the same orientation and scale. Landscape drawings and the organization of those drawings within the Construction Drawing Set include, but are not limited to, those shown in Table 4-1.

Table 4-1 Landscape Construction Drawings

Drawing	Scale	Remarks
General Notes	No Scale	Includes General Notes, Construction Notes, Irrigation Notes, and any special planting notes.
Landscape Plan (Composite)	1" = 50'- 0"	Includes planting areas, mature plant location and size to scale, plant legend and schedule (with botanical names, common names, container size, and quantities), site furniture and legend, and keyed notes. date, revisions, plan scale, bar scale, north arrow, and any additional planting installation details and notes not in the specifications, and square footage of each hydrozone listed individually.
Landscape Enlargement Plan, when applicable	1" = 20'- 0"	Same as Landscape Plan, as needed, and adjacent sheet numbers on applicable plan sheets
Irrigation Plan (Composite)	1" = 50'- 0"	Includes all applicable components (Irrigation Legend, Irrigation Emitter Schedule, Pipe Sizing Chart, Valve Legend, and other items noted in Irrigation Design Drawings below.)
Irrigation Enlargement Plan	1"= 10'- 0"	All applicable components

Drawing	Scale	Remarks
Landscape Planting Details	Not to Scale	SNL Standard Drawing
Irrigation Details	Not to Scale	SNL Standard Drawing

All plans must be complete and show the entire building site with north arrow oriented in the same direction as the Civil Site Plan.

Present details on a separate detail drawing(s). Do not show details on plan or other types of system drawing sheets.

4.4 Landscape Design Requirement

This section describes general Landscape Design guidance. For project-specific requirements, refer to the design criteria, Sandia's Landscape Concepts and Guidelines (June 2014), and/or Sandia's Landscape Master Plan, dated May, 2013.

All areas indicated on the contract drawings must be prepared for the installation of a complete underground sprinkler system or an aboveground temporary sprinkler system, and the planting of trees, shrubs, groundcovers, and appropriate warm- or cool-season grass seeding, stolonizing, or sodding.

4.5 Review Process

Submit design packages in accordance with Chapter 2.0, General Design Standards and Procedures.

4.6 Safety

Design all related landscape site conditions to promote the safety and welfare of the tenants and the public. The design must conform to SNL/CA's security requirements. Consider path lights for safe passage along walks, stairs, and ramps. Refer to Chapter 9.0, Electrical Design, and the SNL/CA *Landscape Master Plan* for more information.

4.7 Accessibility Requirements

Design all new and remodeled landscape areas to be safe, readily accessible to, and usable by individuals with disabilities. Follow the requirements of the *2013 California Building Code,* and the 2010 Americans with Disabilities Act and Architectural Barriers Act *Accessibility Guidelines* (ADA and ABAAG).

4.8 Landscape Design Goals

Sandia National Laboratories understands the value of designing, installing, and maintaining comfortable, attractive surroundings. Use this information to permit the safe and efficient design of landscape including irrigation materials and systems in accordance with industry accepted practices (including AB 1881).

The practice of landscape architecture and construction varies considerably depending on the geographic location, soil characteristics, and microclimate of a given area.

Sandia National Laboratories wants to create and maintain a campus-like atmosphere through the landscape surrounding its buildings and infrastructure. Landscape development should enhance the overall exterior appearance of buildings and related sites while serving as a link connecting buildings, pathways, and the various outdoors spaces of the SNL/CA campus. To achieve this campus atmosphere SNL/CA is providing these design guidelines. The SNL/CA Landscape Master Plan, and Landscape Concepts and Guidelines contain further information on goals and principles for exterior design at SNL/CA, which must be understood and followed. Landscape Design improvements shall be in accordance with the criteria presented in the SNL /CA Landscape Master Plan and examples provided in the Landscape Concepts and Guidelines.

Landscape irrigation and water conservation are long-term requirements at SNL/CA and provide a positive measure of efficiency in their actual performance when measured over time. In addition to compliance with California's AB 1881, design shall emphasize xeriscape principles to minimize maintenance and promote low water usage. This effort can be effective by using a variety of native plant material and grasses. Low-water use shade trees shall be considered to cool environments and make pedestrian areas more usable. Gathering spaces such as outdoor patios and plazas may lend themselves to high-intensity / high-water use landscapes; however, these shall be minimal in size and numbers.

Consider landscaping when designing energy-conservation solutions. Landscape design should reduce solar radiation during the growing season (summer)

4.9 Existing Condition

Evaluate the project site and prepare plans showing all landscape features, including plant material and irrigation heads. Have Sandia Maintenance and Operations activate the irrigation system to determine its operability. As a minimum, the design team must have existing landscape design plans, and Site Survey data in CADD drawings provided by the SNL/CA Project Lead during a site visit to verify the accuracy of information. Collect critical measurements during site visits.

Identify affected areas and potential areas lying outside the limits of construction, such as laydown areas, that might be affected and might need to be restored or revegetated as part of the construction.

Provide additional utility-location methods, such as line spotting, potholing, and excavation, as required to design the project properly. Refer to Chapter 3.0, Civil Design, for more information.

Before designing any landscape or irrigation construction or renovation project, contact the SNL/CA Project Lead who works directly with the ecology SME for guidance as well as SNL Standard Specification Section 013513, Special Project Procedure, and Section 013543, Environmental Procedures, about special provisions necessary to protect wildlife and habitat.

4.10 Landscape Design Considerations

Plan and apply xeric (water efficient) design principles. These principles promote the use of native, well-adapted plant material and reduce maintenance and irrigation requirements. Consider landscape design concepts that incorporate functional water and energy conservation methods. Xeriscape installations can effectively address the valuable water resource proficiently and economically. In the larger design framework, use low-impact design and development principles. See the *SNL/CA Landscape Concepts and Guidelines* for more information. Consider the following areas:

Develop a Plan: Plan the landscape with regard for function, image, and quality. Evaluation factors must include the following:

- Existing Conditions (preserve mature trees)
- Views (enhance positive views)
- Vehicular and Pedestrian Circulation (address safety and logical paths and clear visibility for pedestrians)
- Quality of user experience (improve shading, cooling effects of canopy trees, wind-reduction opportunities)
- Topography (stabilize steep slopes)
- Soils - test soil to confirm suitable pH, electrical conductivity or EC, texture, exchangeable sodium percentage or ECP, and calcium carbonate or $CaCO_3$. Also, recommend the addition of amendments to adjust for soil test deficiencies.
- Utilities (avoid underground utility locations)
- Water Supply as part of the project)
- Drainage (integrate run-off patterns, locate potential ponding areas, and incorporate into planting plans where feasible)
- Security Requirements (observe line-of-sight and required setbacks)
- Wildlife (preserve existing habitat)

Improve Soils: Soils can vary greatly over an installation or even over a job site. A soils analysis determines exactly what improvements might be required. Soils at SNL/CA tend to be very compacted after construction and ripping and loosening the soil is a significant need and should be considered a requirement unless otherwise noted.

Test Soils: Collect samples of soil in planting and seeding areas. Mix and submit a **single composite sample** to a recognized testing laboratory for evaluation of fertility. Testing must evaluate pH, base saturation percentage, ECP, EC, texture, and free lime. Sample turf and planting beds separately.

Conserve Natural Resources: Conservation and protection of the natural resources at the site are important. Keep any disturbance of natural resources occurring during planting operations to a minimum. Consider harvesting existing plants and relocating them to other sites or containerizing (or ball/burlop) and storing them for reuse on the site.

Select Water-Efficient Plants: Use water-efficient plants in appropriate settings. Less xeric plants may be used in gathering areas. Plants that require less water are readily available locally and in surrounding regions and states.

Use Mulches Appropriately: Mulching with open voids (materials with no fines) provides protection and cover around plant material, reduces evaporation, reduces runoff, increases infiltration, cools soil temperatures, and reduces erosion. Trees not located within hardscape plantings (for example, within turf, dirt, or rock or bark mulch areas) must be designed with wood mulch ring bases 4 times the diameter of the root ball to be planted.

Consider Storm Water Pollution Prevention Plans (SWPPPs): To allow SWPPPs to be closed by the end of a given project design, remnant dirt areas must be drill-seeded with native grasses, wildflowers, or both, and covered with a minimal layer of rock mulch. A temporary irrigation system must be installed to support the grasses and wildflowers until they are established with a minimal layer of rock or bark

mulch (not more than 2 inches). SNL/CA is subject to Alameda County C3 requirements for storm water quality. The Design must comply with these requirements.

Design for Maintenance: The design must aid in determining the required maintenance. Designing "smart" allows SNL/CA to manage effectively and maintain its landscaping while using resources efficiently.

Consider Plant Placement Carefully: The placement of trees and shrubs in turf areas should be done with careful consideration of species, mature size, rooting habits and depths, and water requirements.

When trees are placed they must be mulched according to the guidelines provided above in "Use Mulches Appropriately." Do not locate shrubs in turf areas. Locate shrubs so the mature size footprint they produce does not extend into pedestrian or vehicle pathways or interfere with the site triangle/distance at roadway intersections or driveways.

Carefully consider the placement of trees in relation to facility structures and utilities. Underground utilities must be avoided by a minimum of 5 feet in any direction. In case of conflicts with utilities, contact the SNL/CA Project Lead to determine the correct setback of trees and shrubs from the utility in question. When considering planting trees in proximity to gas or sewer lines, plastic or herbicide impregnated root barriers must be considered and used where deemed necessary by the SNL/CA Project Lead.

Because of security issues and plant competition for water, shrub placement together with trees in parking lot islands is to be reviewed with the SNL/CA Project Lead.

Canopy shade trees should be set back 5 feet from any paving, curb, or fixed object. Further, keep larger canopy trees 20 feet from any building edge. Smaller ornamental trees can be 10 to 15 feet from a structure and 5 feet from paving edges. Coordinate placement of canopy shade trees with roadway or pedestrian path lighting.

Design all landscapes so they do not impede visual assessment or allow bridging of any security fence. Specifically, no landscape plants or boulders must be installed within 10 feet of any security fence. See the *Campus Design Guidelines* for more information.

Use curbs or seat walls for shrub beds to reduce trash from being blown into shrub beds.

4.11 Hardscape and Parking Lot Design

Plan and apply rooting volume principles that recognize and promote the relationship between a plant's above ground canopy size and the available rooting soil volume. To achieve near full plant maturity in age and size there must be enough soil volume for the plant to root into. This rooting soil volume can be achieved using one or a combination of several of the methods described in this section.

4.11.1 Hardscape Design

- Do not use structural soil in planting any SNL/CA landscapes.
- Design raised planters so they do not contain large tree species (such as shade trees and large conifers) unless there is enough space for proper root growth over the life of the tree. Specifically, the planter limits must be at least two times the diameter of the mature tree canopy.

4.11.2 Parking Lot Design

Coordinate landscape designs for parking lots with the SNL/CA Project Lead and adhere to the following guidelines.

4.11.3 Tree Sizes

The size of trees planted in any parking lot must be a function of how much uncompacted soil is available in which the trees can root. This space is proportional to the availability of aboveground area not used for parking that can be dedicated to landscaping. Where there is enough space available, large shade trees from the approved plant palette must be used. In locations where space is limited, use medium-sized shade trees and small ornamental trees. Table 4-2 describes the cubic footage requirements to use to determine the sizes of trees that can be planted.

Table 4-2 Tree-Size Requirements for Parking Lots

Tree Size	Requirement
Small Trees	120 to 500 cubic feet of rooting space (maximum 2-foot depth) is required for mature tree canopy spread of between 10 and 20 feet
Medium Trees	500 to 1,000 cubic feet of rooting space (maximum 2-foot depth) is required for mature canopy spread of between 20 and 30 feet
Large Trees	1,000 cubic feet or greater of rooting space (maximum 2-foot depth) is required for mature canopy spread of 30 feet and larger

4.11.4 Design Methods for Achieving Soil Volume

The design method used to achieve adequate soil volume is dictated by the availability of aboveground space that can be left unpaved. The following design methods are listed in preferred order:

- Completely Open Soil Area
- Covered Soil Area using Soil Cells

4.11.5 Other Hardscape Tree Planting Designs

Coordinate landscape designs for pedestrian areas with the SNL/CA Project Lead and adhere to the guidelines listed below.

Designing tree and shrub plantings for pedestrian areas is dependent on the sidewalk width and the amount of space between permanent structures, such as buildings and utilities. Reference the Tree Space Design Matrix on page 9 of the Tree Space Design publication entitled "Growing the Trees Out of the Box," published by CaseyTrees@www.caseytrees.org. With this matrix use the following design methods:

- Completely Open Soil Area
- Covered Soil Area using Soil Cells
- Covered Soil Area Connected to Green Space
- Open Soil Connected to Green Space

4.11.6 Rain Water Harvesting

As appropriate, use of rainwater harvesting and retention is highly recommended. When possible, incorporate rainwater harvesting into parking lot design. Both passive and active systems may be designed. Promote a design that manages and integrates the use of storm water into the landscape. Sandia National Laboratories encourages the capture of roof water, which is typically comparatively clean and disposed of at a single or few locations in a cistern. All rainwater harvesting designs must be done in accordance with the Grading and Drainage Plan and in accordance with SNL/CA policy for the retention and detention of developed storm water flows.

Note that swales are used and function to evacuate and drain water. They can also lower adjacent water moisture. Swales are not a water conservation element by design. Providing small check dams, unpaved areas with minimum acceptable slopes or gradients, and shallow water ponding areas with flat bottoms coordinated with tree locations is encouraged. Reduce or eliminate site runoff, and use the rainfall for trees and shrubs.

Include a grading plan design indicating finished configurations and elevations of the landscape areas, including the height of graded slopes, impoundment areas, ponds, water-recharge zones, percent of slopes, general drainage patterns, pad elevations, and finished grade. Design grading and drainage to create onsite water harvesting wherever possible.

Any rainwater harvesting system that captures and stores water for release under pressure must be designed so that it is integrated into the Centralized Irrigation Control System (CICS) and uses a CICS-compatible flow meter.

4.12 Damage Control and Mitigation

Effective tree and landscape feature preservation must be integrated with the project design and site development. Formulate a plan to identify, limit, and remediate damage to the landscape relative to the proposed project site and its adjacencies by addressing the following Table 4-3 requirements:

Table 4-3 Requirements for Landscape Damage Mitigation

Requirement	Description
Erosion Control	Include mitigation methods for protecting Tree Protection Zones (TPZs) from anticipated erosion matter and storm water runoff.
Excavation	Where encroachment into a TPZ is determined to be unavoidable, include proposed excavation methods.
Irrigation System and Outages	Evaluate effects on systems and plants.
Fencing	Where necessary, temporary fencing (rigid in nature) may be used to protect TPZs and tree canopies from accidental encroachment and damage.
Tree and Shrub Pruning	Prior approval is required. Coordinate with the SNL/CA Project Lead.
Landscape Demolition	Propose a Feasibility Plan for the transplanting or relocation of trees, shrubs, and other landscape features, such as boulders, furniture, and sculptures.
Plant Material Value	Appraise all plant material to be demolished. Suggested guidelines: *Guide for Plant Appraisal* by the Council of Tree and Landscape Appraisers (CTLA), current edition. Pre-damaged conditions must be documented and recorded (that is, photographed). Plant

Requirement	Description
	material damaged or demolished during construction must be replaced and the cost borne by the project. The SNL/CA Project Lead must select locations for the replacement plants and release funding to the General Contractor to subcontract an approved landscape contractor to purchase and install the replacement plants. The SNL/CA Project Lead must approve any plant material used as replacement plants.
Ground Squirrel Damage	Include planting techniques that discourage ground squirrels from repopulating landscaped areas.

4.13 Design Personnel

Landscape Architecture must only be performed by a California Board of Landscape Architects licensed/registered Landscape Architect (RLA) who possesses a current LA stamp or a Council of Landscape Architectural Registration Boards (CLARB) certified individual.

4.14 Irrigation Design Drawings and Review Process

At the beginning of the design process, the SNL/CA Project Lead must contact the SNL/CA Systems Landscape Architect about the upcoming project. Thereafter the SNL/CA Landscape Architect working through the SNL/CA Project Lead, may contact the SNL/CA Landscape Maintenance department to present 30%, 60% and 90% design drawings for its review in accordance with Chapter 2.0.

Irrigation design drawings submitted for review must label and show the location for the following:

1. Point of connection
2. Flow meter location and size
3. Master valve, control valves, and pressure regulators (each valve must be labeled numerically)
4. Backflow prevention devices and sizes
5. Mainline and lateral piping sizes
6. Isolation valves and quick coupler valves
7. Manual drain valves
8. Hose bibs and hydrants
9. Sprinklers, bubblers, drip emitters, filters, control wire routing and sizes, and controller
10. Power supply/electrical access
11. Date, revisions, legend, and scale
12. Irrigation installation details, notes, and specifications
13. Designer's name, address, telephone number, and certification or license number

In addition to the information listed above, Irrigation Plans must have a System Performance Information Chart in Microsoft® Excel® that gives the following information for each control valve:

14. Control valve number
15. Valve manufacturer, model number, and size
16. Irrigation head manufacturer and model number
17. Irrigation head nozzle size
18. Irrigation head radius and spacing

19. Irrigation head gallons per minute and per hour
20. Total gallons per minute/valve
21. Design operating pressure through the valve and at the head
22. Precipitation rate at the design operating pressure
23. Length of time required to operate the valve to apply .25 inches of water

Design of irrigation systems must comply with the California Green Building Code. On Leadership in Energy and Environmental Design (LEED®)-rated projects, submit a water budget showing required reductions in water use from the baseline. Use the Blaney-Criddle formula for evapotranspiration (Et) rates.

All irrigation plans must state the existing static pressure at the meter or point of connection.

The following statement must appear on the face of each irrigation plan: At the time of final acceptance, the Contractor must demonstrate to the SNL/CA Project Lead that the operating pressure at the head has been adjusted to match the specified design operating pressure for each valve.

4.15 Distribution Uniformity

Design and install each system such that its performance enhances distribution and emission uniformity and promotes the efficient use and protection of SNL/CA water resources.

Conduct a distribution uniformity (DU) test using established IA landscape water-auditing guidelines using catch can tests that measure the actual amount of water applied to the target landscape on all irrigation system installations.

4.16 Design Criteria

This section describes factors and requirements that must be considered and included when designing irrigation systems at SNL/CA.

4.16.1 Water Supply

Review all potential water supply sources as part of the irrigation system design process, and advise the SNL/CA Project Lead about the cost and suitability of each. The water supply, if it is other than a potable water system, is tested to identify materials or chemicals that could damage system components, plant material, or cause an environmental or public safety problem.

The water source must be adequate from the standpoints of volume, flow rate, pressure, and quality to the irrigation requirements of the irrigated area, as well as other demands, if any, both at the time the system is designed and for the expected life of the system.

Available Pressure and Capacity:

Potable water systems: If not available from the water provider, determine the available pressure and flow rate from a water supply meter connection by conducting a flow test to measure the pressure downstream of the meter at various flow rates. Consider daily, seasonal, and long-term fluctuations in the supply pressure and available flow when developing a safety factor to derate the flow and pressure measured by the field test.

Design flow rate through the meter must be no greater than 75% of the maximum safe flow capacity as stated by the meter manufacturer or use the American Waterworks Association standards. Where possible, develop a water supply from roof runoff into a cistern or other sources and deliver water using a pump.

4.16.2 Application Rates

Use application rates, scheduling practices, or both, that avoid runoff and permit uniform water application. Consider land slope, soil hydraulic properties, vegetative ground cover, peak use demand, and prevailing winds when specifying application rates.

4.16.3 Application Uniformity

Table 4-4 lists the minimum accepted distribution uniformity ratings for SNL/CA irrigation systems.

Table 4-4 Minimum DU Ratings for SNL/CA Irrigation Systems

System Type	Rating
Rotary systems	75%
Fixed spray systems	65%
Point source systems	85%
Line source systems	90%

The SNL/CA Project Lead works with the SNL/CA responsible department who must commission the irrigation system as a whole. The commissioning must include an irrigation system audit with at least one representative valve (as recognized by IA nomenclature) from each zone type installed (drip, bubbler, fixed spray, or rotor) being audited and passing the minimum DU requirements listed above. Any zone not meeting the minimum target values must be redesigned, reconstructed, or both, until it meets the minimum target values. All zones of the same type that use the same emission devices (drip, bubbler, fixed spray, or rotor) as the failed zone must be audited and be required to meet the minimum DU values in Table 4-4.

4.16.4 Peak Water Use Requirements

The irrigation system must be capable of meeting the peak water use demand of turf and landscape areas. Estimate the peak water use requirement based on the plant species and local climate conditions. If using a cistern, estimate year-round flows. Any overhead spray irrigation system must have the capacity to apply water at a rate that satisfies the peak water demand of the fully mature landscape within 12 hours. If line size is a limiting factor, it must be addressed during the design phase.

4.16.5 System Zoning

Divide the irrigation system into zones based on the following considerations:

- Available flow rate, water velocity, and pressure
- Consistency with hydrosome concepts
- Sprinkler heads with matched precipitation rates

- Type of vegetation irrigated (such as turf, trees, or shrubs)
- Consistency with microclimates (such as buildings, shaded areas, and reflective heat)
- Elimination of mixed head types (such as bubblers and rotaries on the same zone)
- Cultural use of the area (such as pedestrian walks and seating areas)

4.17 Irrigation System Source

The preferred source for landscape irrigation water is from building potable water systems. Coordinate with the Mechanical Designer for location and correct pressure of irrigation water needed for landscaping. Evaluation of alternate sources (harvested rainfall, cisterns, and so on) is encouraged. If alternate sources are used, include in the water budget if a LEED-rated project.

4.18 Irrigation Equipment Selection – General

Select equipment consistent with SNL/CA's landscape requirements and central irrigation control system (CICS).

Select equipment, when available, that is labeled WaterSense by the EPA. The project Landscape Architect must consult the EPA WaterSense web site to look for products that are labeled WaterSense.

Design sprinkler and bubbler irrigation systems to meet water requirements for individual plants at maturity.

4.18.1 Controller

Select a controller capable of handling the required zones with a minimum of two additional spare zones. See the SNL/CA Standard Specification *328000, Irrigation*.

Design as recommended in the *Calsense® Designers Guide* available from Calsense, Inc. at (800) 573-8608

Ensure the irrigation system design incorporates CICS either with a new controller and flow meter installation or by using an existing controller and "tying" the new system into the existing one.

Projects that include construction of a new building must specify that the Calsense controller communicate using internal Ethernet modem back to central. The Calsense controller must be specified in the following manner: ET2000E - # of stations desired – EN – RRe – F.

4.18.2 Controller Enclosure

The preferred enclosure for the Calsense controller is the pedestal-mount heavy-duty stainless steel enclosure. When this option is not possible, installing the standard wall mount enclosure is acceptable.

4.18.3 Wiring

- Refer to Standard Drawing LP5002, "Irrigation Details."
- Show wire route and size on plan.

- Install one extra wire to each valve in the same trench as the other zone wires.

4.18.4 Backflow Preventers

Backflow-preventers (BFPs) must be approved by SNL/CA. Refer to section 7.3, "Fire Protection Backflow Preventers," in this *Design Standards Manual*. Apply the devices in accordance with local Fire Jurisdiction requirements, section 8.6.6 of this manual, and the following guidelines:

- Double-check assemblies are **not** permitted for use on irrigation systems.
- Wilkins backflow preventers must be specified. Pressure gauges with isolation valves should be installed in the inlet and outlet piping to the backflow preventer.
- Backflow preventers may be installed in building's mechanical room.

4.18.5 Pressure Regulating Valves

Provide an adjustable brass pressure-regulating valve (PRV) on all projects downstream of the point of connection and upstream of the backflow preventer. The PRV can be located in any position (for example, horizontal or vertical). Individual pressure regulators must be used on zones requiring low pressure (drip or low-flow bubblers).

4.18.6 Flow Meter

Flow meters must be used in all irrigation applications using the CICS. Consult with the SNL/CA Project Lead about the use of a flow meter on any given irrigation system. This consultation must occur regardless of the water source—potable or nonpotable.

4.18.7 Master Valves

Normally closed master valves must be used on all irrigation systems.

4.18.8 Quick Coupler Valves

Quick-coupler valves must be installed as needed or a minimum of every 100 feet of mainline as per SNL Detail Drawing LP5002STD.DGN #14.

4.18.9 Drain Valves

Automatic drain valves are not acceptable. Use one manual drain valve in the low point of each lateral and mainline piping.

4.18.10 Piping

SNL/CA Standard Specification 328000, *Irrigation*, specifies materials, processes, and installation requirements for subgrade irrigation systems that apply as designated on the contract drawings.

All pipelines must be sized and routed to limit pressure variations, so the operating pressure at all points in the irrigation system is in the range required by the manufacturer for uniform water application.

As a safety factor against surge or water hammer, the working pressure must not exceed 72% of the pressure rating of the pipe with the pipeline water velocity limited to 5 feet per second.

Design the system with the appropriate size pipe to limit variations in operating pressure between the first and last emission devices (sprinklers, bubblers, drip) on a given zone to 20% or less.

4.18.11 Fittings

Male adapters must not be used to connect valves; use toe nipples instead.

4.18.12 Multioutlet, Point Source, and Line Emitters, and Bubblers

As a general rule, all plant material must be designed using a multioutlet point source (MOED) emitter system. Only dense planting beds must be designed using a line source emitter system.

All trees and shrubs must be designed with drip/micro irrigation systems unless specified otherwise. The drip system for trees must use two ball valves to divide the system into sections—one for the first 1 to 5 years of establishment and the second for 6 years and older of maturity. Reference Irrigation Detail Drawing LP5002STD.DGN #13.

Use pressure-compensating emission devices only in instances where elevation changes warrant them.

The location of drip emitters or bubblers is important in proper water distribution and in allowing the plant to mature fully. Evenly distribute emitters around the root ball at least 12 inches from the outside edge of the root ball.

Account for differences in plant Et rates by using different nozzle size emitters or using greater or fewer emitter numbers.

Group plants on a given zone according to type, size, and Et rates, for example, trees and shrubs should not be placed on the same valve.

4.18.13 Spray Heads

Design all spray head irrigation systems using Matched Precipitation Rate principles.

In turf areas, use a triangular-spaced spray head system when possible.

All fixed-spray sprinkler systems must be designed using in-head check valves and in-head pressure regulators.

All fixed-spray and bubbler irrigation systems must be designed with pressure-compensating devices.

Does not use spray irrigation heads when designing for areas less than 10 feet in any direction.

Space sprinklers to prevent overspray onto adjacent property, nonirrigated areas, walks, roadways, or structures. Heads must be located 8 inches from any hard surface.

Use a minimum 4-inch pop-up fixed spray head in all cool season turf areas. Use a minimum 6-inch pop-up fixed-spray head in all native or warm season turf areas.

Specify fixed-spray heads that have fixed-arc nozzles whenever possible. Adjustable-arc nozzles must be used only when odd arcs are required.

Provide fixed-spray heads connected to the same control valve with matched precipitation rates to guarantee application of water at the same rate.

Provide fixed spray heads with automatic flow shut-off devices in areas where damage from pedestrians or vehicles might occur.

4.18.14 Rotary Sprinklers

Design all rotary spray head irrigation systems using Matched Precipitation Rate principles ensuring that the radius of throw is constant regardless of the arc.

Provide rotors that have the smallest practical radius to reduce wind drift.

Impact rotary heads are not acceptable for use.

A triangular-spaced spray head system is preferred for use in turf areas when possible.

All rotary-head sprinkler systems must be designed using in-head pressure regulators. In locations of changing elevations, the system must be designed using check valves at the base of each head to eliminate or reduce low-head drainage.

Locate rotor sprinklers 8 inches away from sidewalks, edges of paved areas, and adjacent walls, buildings or fences.

Use a minimum 4-inch pop-up rotary head in all cool season turf areas.

Use a minimum 12-inch pop-up rotary head in all warm season turf areas.

Provide rotors with automatic flow shut-off devices in areas where damage from pedestrians or vehicles may occur.

A triangular-spaced rotary head design must be applied to large turf areas where overthrow of the sprinklers is not a concern (no buildings or hard surfaces).

4.18.15 Miscellaneous Parts and Components

Refer to SNL Standard Specification Section 328000*Irrigation*, and Facilities Standard Drawings LP5001001STD and LP5001002STD for listing and additional irrigation equipment requirements. These requirements include the following:

- Ball Valve
- Electric Valve
- Manual Drain Valve

4.19 Reclaimed Water Guidelines

When a project has reclaimed water available or is in an area that will have reclaimed water available as irrigation water, install the irrigation system using the industry standard purple color, pipes marked "Reclaimed Water – Do Not Drink," or both, valves boxes, and sprinkler heads.

Meter the backup potable water supply.

The backup supply water is only to be used in emergencies when reclaimed water is unavailable. Protect the backup water supply with the appropriate backflow prevention device. If a project is to be LEED-certified, include reclaimed water in the water budget.

Control valves using effluent water must not have an external manual bleed.

4.20 Irrigation Scheduling

Proper irrigation scheduling applies the correct amount of water at the correct intervals for optimum growing conditions for plant material. A schedule must define the time of day, days of the week, and length of time a zone is operated to apply water.

Develop an irrigation schedule that accounts for the effects of temperature, plant species, soil types, precipitation rates, and microclimates. (Either the project Landscape Architect or Irrigation Designer develops this schedule.)

Base schedules must be developed for each zone/station/month for the first 12 months after installation. Use the following criteria to develop base schedules:

- Runtimes per zone/station
- Cycles per day
- Days per week or frequency

Changes in irrigation frequency in response to changes in Et must be reflected by increasing or decreasing the frequencies rather than changing the length of the run time. These changes must be reflected on monthly schedules for an entire year.

When water application rates exceed soil infiltration rates, determine the run time before run-off occurs and incorporate this variable into the schedule.

The schedule must use the principles approved and used by the Irrigation Association in its Landscape Irrigation Auditor Program, the Green Building Code, and the LEED system, if applicable.

4.21 Schedules, Charts, and Legend

Schedules of equipment or plant material must be complete, well-organized, and representative of industry standards.

5.0 Structural Design

5.1 Introduction

The requirements of this Chapter apply to the structural phase of every applicable design project performed for Sandia National Laboratories California (SNL/CA).

For all new buildings and major modifications to existing facilities, the design shall conform with DOE-STD-1020-2012 (Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities).

This Chapter may be supplemented with the requirements of an applicable project specific Design Criteria. Information contained in a project specific Design Criteria shall take precedence over the design requirements of this Chapter.

For all general requirements associated with the design phase of a project, see Chapter 2, General Design Standards and Procedures.

For all product specifications, see the SNL/CA Standard Specifications.

5.2 Design Requirements

5.2.1 General

The following is an outline summary of the general structural requirements that the Engineer of Record (EOR) shall consider for each project design. At design completion, the EOR shall record the following information on the General Structural Notes sheet of the project's construction drawings:

- Brief narrative description of the building's substructure and superstructure
- Brief narrative of all special structural features
- Codes and Manuals used for design and construction
- Building Type of Construction
- Seismic Design Category per DOE-STD-1020-2012 and ANSI/ANS-2.26-2004
- Wind Design Category per DOE-STD-1020-2012
- Risk Category per ASCE 7-10 Table 1.5-1
- Design loading criteria with detailed coefficients and factors
- Geotechnical Report reference
- Brief narrative of key geotechnical information used for design and construction
- Outline specifications of construction materials and methods
- Statement of Special Inspections required to verify construction complies with design
- List of all mechanical/electrical/other equipment that has been seismically anchored / protected
- Fall protection structural information
- Identify load capacities for all conveying systems such as elevators, cranes, and hoists.
- Schedules, Tables, Diagrams that enhance the presentation of the scope of work

- List of computer files used for design, including archive location information
- Abbreviations
- All other pertinent structural information

5.2.2 Applicable Codes / Design Standards

- DOE-STD-1020-2012 (Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities) governs the design of new buildings and major modifications of existing facilities.

  NOTE SNL/CA is considered a "non-nuclear" facility and projects shall be designed in accordance with DOE-STD-1020-2012, Section 2.1 unless project includes significant chemical or toxicological hazards, in which case, DOE-STD-1020-2012, Section 3 shall be followed.

- ANSI/ANS-2.26-2004 (Categorization of Nuclear Facility Structures, Systems and Components for Seismic Design).
- California Building Code (latest edition).
- ASCE/SEI 7-10 (Minimum Design Loads for Buildings and Other Structures) – Seismic provisions should be followed for projects with Seismic Design Categories SDC-1 and SDC-2.
- ASCE/SEI 43-05 (Seismic Design Criteria for Structures, Systems and Components in Nuclear Facilities) - Seismic provisions should be followed for projects with Seismic Design Categories SDC-3, SDC-4 and SDC-5 (generally not applicable to projects at SNL/CA).
- ASCE/SEI 31-03 (Seismic Evaluation of Existing Buildings).
- ASCE/SEI 41-06 (Seismic Rehabilitation of Existing Buildings).

Note if there exists any conflict between the requirements of DOE-STD-1020-2012 and the California Building Code or any local regulation, code or standard, the requirements that result in the more conservative design must be used.

5.2.3 Building Type of Construction

NOTE The building's Type of Construction is obtained from either the project's Architectural Code Analysis or the latest version of the California Building Code (CBC).

5.2.4 Seismic Design Category

The criteria for determining a project's Seismic Design Category (SDC) is described in DOE-STD-1020-2012 and ANSI/ANS-2.26-2004.. For a preliminary SDC determination, the following SNL/CA guidelines can be used:

Table 5-1 Preliminary Schematic Design Category Determination

Category	Use
SDC-1	General use buildings such as office buildings, cafeterias, storage buildings, laboratories, etc. (Risk Category II of ASCE/SEI 7-10).
SDC-2	Essential Facilities and Facilities that with chemical or toxicological hazards . (Risk Categories IV of ASCE/SEI 7-10).
SDC-3, 4 or 5	Nuclear Facilities (Generally not applicable for SNL/CA).

The SNL/CA Project Lead shall determine the building's SDC and obtain DOE concurrence.

5.2.5 Design Loads

Use the design loads set forth in ASCE/SEI 7-10 (Minimum Design Loads for Buildings and Other Structures) except for seismic loads associated with facilities designated as Seismic Categories SDC-3, SDC-4 and SDC-5.

Use the seismic design loads set forth in ASCE/SEI 43-05 for facilities designated as Seismic Categories SDC-3, SDC-4 and SDC-5 (generally not applicable to facilities at SNL/CA).

For the seismic evaluation and rehabilitation of existing facilities use the design loads / procedures set forth in ASCE/SEI 31-03 and ASCE/SEI 41-06.

All interior partition walls shall be designed and detailed to support attached commercial shelving units and / or casework as detailed on the architectural drawings. Design loads shall be as set forth in ASCE/SEI 7-10 Chapter 13.

5.2.6 Geotechnical Information

ASCE/SEI 7-10 (Minimum Design Loads for Buildings and Other Structures)

NOTE Seismic Design Category D shall be used for all projects at SNL/CA.

Seismic Evaluation and Rehabilitation of Existing Facilities

Projects that involve the seismic evaluation of an existing facility at SNL/CA shall follow the procedures set forth in ASCE/SEI 31-03.

Seismic rehabilitation shall be governed by the procedures set forth in ASCE/SEI 41-06.

5.2.7 Protection for Systems and Equipment

Seismic protection for systems and equipment shall be provided for all new buildings.

The design of protection (anchorage and bracing) shall be in accordance with ASCE/SEI 7-10 Chapter 13. Seismic protection for systems and equipment in existing buildings shall be determined by the EOR based on the CBC criteria for Seismic Design Category and for the extent of renovation.

When the EOR determines that seismic protection for systems and equipment is required, detailed design shall be accomplished by the following two phases:

5.2.7.1 Phase 1

This phase requires the EOR to design seismic protection for all major systems and equipment that normally must be considered in the design of the structure as a whole. Large and/or heavy systems and equipment with known weights and locations that are input criteria for the analysis and design of their supporting structures shall have their seismic protection designed concurrently. Anchorages that resist seismic overturning and sliding forces shall include, but not limited to, anchor bolts, vibration isolators, and multi-directional snubbers. Products that resist lateral and longitudinal seismic forces and/or accommodate building drift or other displacements shall include, but not limited to, sway braces, spacers, pipe sleeves, and flexible joints or couplings. The EOR shall clearly identify all the systems and equipment in the General Structural Notes that required special design and detailing. The EOR shall clearly detail all seismic protection within the project's construction drawings and is encouraged to edit SNL/CA Standard Specification 200548 "Seismic Protection" to specify these special seismic protection products and/or special requirements. The EOR shall also identify required seismic bracing submittals on the SNL/CA Descriptive Submittal Lists.

5.2.7.2 Phase 2

This phase requires the General Contractor (GC) to design seismic protection for 1) the fire protection system and 2) all other minor systems and equipment. Fire protection systems shall be designed according to NFPA 13 Specification Section 9.3. SNL/CA Standard Specification 200548 "Seismic Protection" shall be the basis of seismic design for all the other minor systems and equipment. These two Specifications, plus the seismic design criteria listed in the General Structural Notes by the EOR, will give the GC sufficient information to either contract the design and detailing of the seismic protection to a Registered Professional Engineer or to follow the seismic detailing as illustrated on the SNL/CA Standard Drawings. These Standard Drawings graphically summarize the latest seismic protection requirements listed in the applicable codes and are usually included within the project's construction drawing package. Construction compliance with these Standard Drawings usually eliminates the need for a Registered Professional Engineer to design the seismic protection for minor systems and equipment.

5.2.8 Fall Protection Anchor Points

Fall protection anchor points for all new and existing buildings, for exterior and interior applications, shall be determined by the EOR based on project specific criteria and shall be in compliance with ANSI/ASSE Z359.1, Cal OSHA Section 3212, and any applicable local rules or regulations

For exterior roof-top applications, fall protection anchor points are generally not required for buildings with a continuous perimeter parapet or guardrail of at least 42" minimum height measured vertically from roof surface level nor where all serviceable equipment is a minimum of 15' from the edges of the roof

For all other exterior and interior applications, fall protection anchor points shall be designed for project specific conditions.

- Anchor points for fall protection in new structures shall be designed for an ultimate load capacity of 5000 lbs (3600 lbs service load) applied in any direction.

5.2.9 Cranes, Monorails, and Hoists

Cranes, monorails, and hoists shall comply with the latest edition of CMAA 70 as applicable for the type of device. The EOR shall be responsible for coordinating the design and detailing of all cranes, monorails and hoists. The design shall address the following SNL/CA guideline list of criteria and features, as applicable for the type of device:

- Crane capacity
- Crane class
- Top running or under hung
- Bridge crane clearances
- Girder type
- Bridge speeds
- Bridge drive type
- Hook height
- Trolley speeds
- Hoist class
- Hoist lift
- Hoist speeds
- Pushbutton pendant stations

Other features that may need to be addressed include the following:

- Effects to any existing building structural system (foundations, columns, etc.)
- Special Pendant Travel System
- Pendant Retractor System
- Personnel catwalk along the bridge
- Ladder with platform to the catwalk

5.2.10 Elevators

Elevators shall be in compliance with the latest edition of ASME 17.1. The EOR shall be responsible for coordinating the design and detailing of all elevators. As a minimum, the EOR shall address the design criteria as described in Chapter 6 Architectural Design Standards Chapter 6.3.5 and also as contained in Construction Standard Specification 142400 Hydraulic Elevators.

5.2.11 Structural Calculation Requirements

At design completion, the EOR shall copy, neatly index and bind, and submit all structural calculations and related documentation required for and resulting from the project's structural design and detailing, to the SNL/CA. This information will be archived in the SNL/CA Facilities' Library for permanent record.

In addition to the information summarized on the General Structural Notes Sheet, the submittal should capture information such as:

- Project requirements, criteria sources, and references
- Allowances for future loads
- Working or ultimate stresses and factors of safety
- Codes, manuals, special investigations, and reports used
- Calculations with loading, shear, and moment diagrams
- Computer input and output with forces and stresses tabulated
- Explanations for assumptions used and conclusions drawn
- Deflection calculations and tabulated results
- Applicable expansion, contraction, and crack-control measures
- Geotechnical report discussions

5.3 Construction Drawings

5.3.1 Structural Drawings

Accurately prepare structural drawings to scale with all plans at the same orientation and scale. Refer to the Facilities CADD Standards Manual for all CADD requirements.

Present sections, details, and/or other unique graphical presentations on separate drawing sheets.

5.3.2 Drawings Required for Building Construction

The following is an outline list of drawings required for the typical project. Additional drawings may be necessary. Arrange drawings in the order listed.

1. **General Structural Notes Sheet:** Describes the structural design intent of the project.
2. **Structural Typical Details:** Include typical foundation details; typical concrete details; typical wood framing details and schedules; typical masonry details; and typical structural steel details.
3. **Foundation Plan(s):** All structural work for the foundation and footing construction. Use the highest elevation of the major ground floor slab as the reference place for drawing the foundation plan.
4. **Floor Framing Plan (s):** Floor framing plans for each level showing member sizes, floor openings and depressions and reference all appropriate details / elevations Sheet notes as required.
5. **Roof Framing Plan:** Plan shall show roof slopes, member sizes, roof openings and reference all appropriate details / elevations Sheet notes as required.
6. **Partial Plans:** Large scale plans where required to clearly explain the structural work.
7. **Miscellaneous Plans:** Additional plans as required to show other work (i.e. anchorage of equipment; light-gauge cold formed steel framing, etc).
8. **Structural Elevations:** Include braced and moment frames, shear walls, etc.
9. **Structural Details / Schedules / Sections:** Organize by type of material (i.e. concrete, steel, masonry, etc).

6.0 Architectural Design

6.1 Introduction

The following design standards generally apply to the architectural phases of all projects. For general requirements for all project phases, see chapter 2, "General Design Standards and Procedures." For specific project requirements, see the Project Requirements Document, the design criteria, or the project scope.

6.2 Architectural Construction Drawings and Specifications

Architectural drawings for construction will include quantitative information. Qualitative information should be described in the accompanying project specifications and should not be duplicated on drawings.

6.2.1 Architectural Construction Drawings

Table 6-1 Architectural Construction Drawings

Drawing	Scale	Remarks
Code Footprint	To fit on sheets with complete legibility	If insufficient room is available to fit the Code Footprint on one sheet, it may be separated. (See subsection 6.2.2 for Code Footprint Requirements.)
Architectural Site Plan	Consistent with civil plans	Can be combined with civil and utility information, provided architectural elements are clearly defined.
Demolition and Removal Plans	1/8" = 1-0"	
Composite Floor Plans	To fit on sheet	Provide one plan per level in a scale that shows the entire layout on one sheet.
Floor Plans	1/4" = 1-0"	
Floor Finish Plans and Schedule	1/4" = 1-0"	Include information about materials, colors, and manufacturers. Coordinate with SNL/CA Project Lead.
Reflected Ceiling Plans	1/4" = 1-0"	Include ceiling pattern layout with locations of sprinkler heads, lights, diffusers, registers, speakers, motion sensors.
Roof Plans	1/4" = 1-0"	
Exterior Elevations	1/4" = 1-0"	
Interior Elevations	1/4" = 1-0"	Provide interior elevations when mounting heights and the coordination of wall-mounted items cannot be clarified in schedules.
Building Sections	1/4" = 1-0"	
Wall Sections	1/4" = 1-0"	
Enlarged Plans	1/2” – 1-0”	Show enlarged toilet plans and toilet accessory schedules on the same sheet.

Drawing	Scale	Remarks
Stair and Elevator Plans	1/4" = 1-0"	
Stair and Elevator Sections and Details		Sections can be ¼" = 1'-0." Details must be 1-1/2" = 1'-0" or larger.
Exterior Details		Sections can be ¼" = 1'-0." Details must be 1-1/2" = 1'-0" or larger.
Interior Details		Sections can be ¼" = 1'-0." Details must be 1-1/2" = 1'-0" or larger.
Door and Window Drawings		Include schedules, elevations, and details.
Equipment and Furniture Layout Plans	1/4" = 1-0"	
Room Finish Schedule		Include finish material legends.
Signage Drawings		Include plans, elevations, sections, and large-scale drawings as needed to coordinate signage.
Signage Schedules		

Present all building plans at a scale determined by the SNL/CA Project Lead, unless noted otherwise in Table 6-1. See the *CADD Standards Manual* for additional information.

All plans must be complete with labeled column or grid lines and north arrows. Include a scaled key plan, oriented in the same direction as the floor plan, on each partial plan sheet.

Present details on separate detail system drawings sheets. Do not show details on plan or other types of system drawing sheets.

6.2.2 Code Footprint Requirements

Provide a code footprint for all large projects and smaller projects that deal with Health, Safety, and Welfare of the public. Existing code footprints must be updated on a project-by-project basis. Code footprint requirements for small projects must be negotiated with the SNL/CA Building Code Official and Fire Marshal.

6.2.2.1 Code Footprint Submittal Format

- Provide full-sized drawing sheets with code footprint information appropriate to the size of the project within the contract document set.
- Complete code footprint floor plan (including existing and new) of each floor of the facility.
- Complete site plan (including partial existing adjacent building footprints) of surrounding buildings and structures.
- All sheets must be sealed, signed, and dated by a California licensed Architect..
- Provide an 11" x 17" sealed reduction of the full-sized drawing.

6.2.3 Code Footprint Minimum Documentation Requirements

6.2.3.1 Information Required on Code Footprint Sheets

- A graphic bar scale
- North arrow
- All permanent partitions 5'-9" or taller
- Each room numbered and labeled. (Keynoting or legends are not acceptable.)
- Occupant load under the room name
- Common path of travel liner notation with exiting count per exit
- Identification of new construction, building additions, existing to remain, remodeled areas, and areas relocated
- Stair and shaft enclosures with minimum fire-resistive openings allowed
- Ramps, landings, and railings
- The perimeter of all rated corridors with minimum fire-resistive openings allowed
- Occupancy separations or protection from hazards
- Fire-rated area separation walls
- Separation of construction types
- Required opening ratings
- All horizontal exits or smoke partitions with opening ratings
- Location of central fire alarm control panel and any remote annunciator panels
- Fire department supply connections and access roads
- Distances to property line
- Distances to adjoining buildings when within 60 feet
- Location of any anticipated future additions (dotted lines)

6.2.4 Minimum Information Required on Code Footprint Sheets

- Indication of which codes the new construction work is designed to (CBC and family of codes and any additional DOE/SNL regulations specifically applicable to the building use).
- Type of construction: New, addition, renovation, changes in use
- Reason for submittal: New construction, new licensure, or plan of corrections
- Location: Street name, Customer information: Name, organization, office location, phone, facsimile number
- Date of plan edition (or revision)
- Name of local fire department (Alameda County Fire Department)
- Name of local building inspection department (when available)
- Each portion of a building on each side on a compliant fire-resistive area separation
- Walls, new or existing
- Each occupancy group and type
- Construction type

- Total allowed area per floor
- Actual floor area
- Approximate grade elevation at each corner of the building and finish floor
- Allowed stories and height limitations
- Actual height
- Mixed-ratio calculations, as required
- Structural fire protection ratings
- Interior bearing walls
- Exterior bearing walls
- Exterior nonbearing walls
- Structural framing information
- Permanent partitions
- Shaft enclosures
- Floors
- Roofs
- Exterior openings
- Proposed UL, FM, or other Fire-Assembly Numbers (if available)
- Fire safety features including the following: Sprinklers, standpipes, fire alarms, and fire extinguishers
- Smoke detectors, battery emergency lighting, exit lights, emergency power generators
- Hood-Suppression Systems; any other special systems, fire lanes, disconnect switches
- Locations and fire department connections
- Accessible building and site features related to the Architectural Barriers Act
- Plumbing fixture type and count

6.3 Architectural Design Requirements

The following information is general guidance. For project-specific requirements, see the design criteria.

6.3.1 Site Development

6.3.1.1 Site Furniture

See the *Campus Design Guidelines* (CDG) for Sandia National Laboratories California (SNL/CA) and SNL/CA Standard Specification 129323, *Trash and Litter Receptacles.*

6.3.1.2 Exterior Signage

See the *Campus Design Guidelines* and the *Sign Standard for Exterior and Interior Signs (ATI cannot locate this standard)*.

6.3.1.3 Site Lighting

See chapter 9, "Exterior Lighting Systems Design," and the *Campus Design Guidelines*.

6.3.2 Building Subculture

6.3.2.1 Foundations

Refer to the Project Geotechnical report for specific requirements. Provide for waterproofing of foundation with membrane under foundation or other actions. Grade the site to drain surface water away from the building. Protect masonry walls below grade against leakage by using suitable cement parging and bituminous coatings or membrane applications.

6.3.2.2 Perimeter Insulation

See SNL/CA Standard Specification 072400, *Exterior Insulation and Finish Systems.*

6.3.2.3 Waterproofing and Wall Vapor Retarders

See SNL/CA Standard Specification Division 07 – Thermal and Moisture Protection

6.3.3 Building Shell

6.3.3.1 Exterior Walls

Use lightweight materials for floors, walls, partitions, and other building components where consistent with programmatic or operating requirements, economic objectives, fire protection and other safety requirements, and where no overriding acoustical requirements exist.

If the wall is to act as a filler or curtain wall, the connections to the structure must be capable of allowing the structure to deflect and yet maintain structural and weather-resisting integrity.

For exposed exterior walls, consider masonry composite walls, insulated metal, or concrete panels and other prefabricated wall construction.

Where side-hill sites require use of concrete retaining walls, use these walls as building walls where practicable to achieve economy in construction.

Where the lower portion of exterior walls is subject to damage from vehicle traffic, material handling, or other activities, select a proper material and material thickness, or possibly provide a protective wainscot. Protect exposed insulation, light-metal construction, or frangible materials from activities that could cause damage.

Design story heights and bay sizes to accommodate coursing. Lay out masonry walls in even coursing to fit between beams, columns, and standard-size openings to minimize cutting of masonry units.

6.3.3.2 Exterior Finishes

In general, exterior finishes should be kept simple. Concrete walls should be left natural and unpainted, unless economical finishing methods can be employed or where aesthetics and operating considerations require finishing. When using color treatment on exterior walls, select colors to harmonize with the environment and natural setting. Limit the number of colors used for a building or complex and carefully select them to provide a dignified public image. Contact the SNL/CA Project Lead for approval of color and material selections.

6.3.3.3 Expansion Control

Provide adequate control and expansion joints when poured concrete floors or concrete or masonry walls are used. In long walls, carefully design and locate control joints to confine the effects of total expansion and contraction. In addition, provide necessary bond beams and anchors to structural framing for masonry units, and provide flashing, bond breaks, and weep holes to minimize the potential for moisture buildup and cracking because of differential movement.

Provide joints across buildings larger than 200 feet in length and where buildings have a significant change in plan dimension. Provide joints that can accommodate thermal-, moisture-, and seismic-related movements. Structural expansion joints should extend from the roof to the foundation without offsets. Building expansion joints should not be less than 1-inch wide and should be designed to permit independent vertical and horizontal movements of the elements on either side of them.

Investigate manufacturers' research data and recommendations to realize optimum performance of various materials.

6.3.3.4 Joint Sealers

See SNL/CA Standard Specification 079200, *Joint Sealants*.

6.3.3.5 Painting

See SNL/CA Standard Specification 099100, *Painting*.

6.3.3.6 Waterproofing and Dampproofing

Protect masonry walls above grade against moisture penetration by means such as the following:

- Adequately filled, compressed joints
- Cement coatings
- Lintel and sill flashing
- Flashing or weather-break offsets at spandrels
- Overlapping weather-breaks where masonry abuts columns and beams

6.3.3.7 Vapor Retarders and Insulation

In general, the "U" factors for insulation should meet the requirements set forth in the 2012 IECC and the 2013 California Energy Code, Title 24, Part 6. Where composite walls are used, consider the compatibility of the insulating and facing materials. Vapor barriers and fibrous insulation must be

noncombustible or labeled by Underwriters Laboratories® (UL) as meeting a Flame Spread Rating of 25 or less and a Smoke Developed Value of 50 or less. For cavity walls, the use of treated (water-repellent), granular fill might be appropriate. Rigid-board insulation of cellular materials generally retains its insulating values longer than fibrous materials that are more vulnerable to moisture.

Foamed-plastic insulation in exterior walls must be separated from the interior of the building by 5/8-inch, type-X, fire-rated gypsum board, or an equivalent fire barrier.

Vapor barriers might be required in buildings with high winter humidity loads. Use the barriers with insulation, and locate them to avoid condensation in the insulation.

6.3.3.8 Parapets

Tops of parapet walls must be capped with metal prefabricated roof specialty components.

6.3.3.9 Building Numbers

Provide building numbers on each major elevation as needed to be visible from approaching vehicles and pedestrians. Provide building number on sign exterior to building to be consistent with SNL/CA site signage.

6.3.3.10 Roof Construction

For single-sheet metal roof decking, specify a minimum thickness of 20 gauge unless otherwise required by Factory Mutual® (FM) for Class I roofs. Design the decking to limit deflection and protect the roofing from subsequent damage. Avoid using lightweight concrete over a metal deck.

Expansion Control

Expansion joints in the roof assembly (including the roof deck) must be placed in the same location as the building's structural expansion joints. The joints must extend across the entire width of the roof and must never terminate short of the roof edge or perimeter. The joints must be designed to accommodate contraction as well as expansion. Expansion joints should always be provided at the following locations:

- Where expansion joints are provided in the structural system
- Where steel framing, structural steel, or decking change direction
- Where separate wings of L, U, T, or similar wings exist
- Where the type of decking changes (steel to concrete)
- Where additions are connected to existing buildings
- Where movement between vertical walls and the roof deck might occur

Locate expansion joints at roof high points; water should drain in opposite directions from each side of the joint. Elevate the expansion joint above the highest expected level of water flow to prevent obstruction of water flow off a roof.

6.3.3.11 Decks, Slabs, and Sheathing

Coordinate design materials and methods with SNL/CA Project Lead.

6.3.3.12 Vapor Retarders and Insulation

As a general guide, vapor retarders should be considered when both the outside average January temperature is below 40°F, and the expected interior winter relative humidity is 45 percent or greater. The building usage must be considered in determining the need for a vapor retarder.

If vapor retarders are used, they should be constructed of materials that are compatible with the other roof system components. The designer should pay particular attention to flashing details at edge seals and at all penetrations through the vapor retarder to ensure its moisture-tight integrity.

Use only insulation approved for UL Class A and FM Class I roof construction on roofs. All roof insulation must comply with the *NRCA Roofing Manual* published by the National Roofing Contractors Association.

Roof insulation should be installed in two layers when thickness permits, with all joints offset between the upper and lower layers. Mechanical fasteners should be used over steel decks to attach the first layer of insulation. For concrete decks, the first layer should typically be hot asphalt mopped to the concrete. The second layer should be fully adhered to the first layer and generally have the higher insulation value. The long dimension of the insulation boards should be laid perpendicular to the flow of water.

Performance type specifications should be avoided when specifying any insulation since manufacturers' data may vary considerably. The designer should list the appropriate ASTM specification, the thickness requirement, and the C or R value for any insulation board to be used in roof construction.

6.3.3.13 Roof Covering

Roof membranes must either Built-up, Batten Seam Sheet Metal, 60-mil single-ply type of TPO or PVC depending on the roof construction and type of building. The SNL/CA Design Criteria must provide guidance in deciding the type of membrane to be specified. In addition, SNL/CA applicable standard specifications, contained in the SNL/CA Standard Specifications Division 07, Thermal and Moisture Protection for each type of roof membrane must be used in their entirety. Any modifications to the specifications must be brought to the attention of the SNL/CA Project Lead. UL Class A ratings are required for all roof membranes.

6.3.3.14 Flashing

Membrane flashing materials must exhibit some degree of flexibility, be compatible with roofing membrane material, be resistant to traffic and natural damage, and be durable and weather-resistant. In general, they should be constructed with materials similar to those used in the construction of the roof membrane. Minimum heights of base flashings should be 8 inches.

Accessory metal should be used for covers, watersheds, or fascia, but typically should not be incorporated into the roofing membrane. Minimize direct contact of dissimilar metals to avoid electrolytic action.

Surface-mounted wall reglets are to be used in lieu of embedded types. Positive attachment using screws or bolts is required.

6.3.3.15 Drainage

Design and build all roofs to ensure positive, thorough drainage. The designer must make provisions for positive drainage per the NRCA guidelines. The structural framing, deck type, roof membrane, roof deflections, and building layout must all be considered in determining the necessary slope.

Locate drains at points of maximum deflection (that is, midspan) and not adjacent to columns, load-bearing walls, or any other structural member supported by the ground. If drains are required to be placed at columns or bearing walls, the slope of the roof must be increased to compensate for the minimum deflections at these locations. Roof drain spacing must not exceed 75 feet in any direction. After drain locations are selected and deflections computed, the designer must provide additional slope to ensure positive drainage. A minimum slope of 1/8 inch per foot should be added to the deflection computation. Structural decks that incorporate camber (precast concrete) must be considered in the design of the drainage slope system.

Drains should be recessed (sumped) below the roof surface with sufficient insulation placed around the drains to prevent condensation. Drainage crickets should be provided between drains and on the high side of mechanical curbs. Provide roof drains with a minimum 4 inch-diameter pipe size in lieu of gutters and downspouts. Provide a secondary drainage system (overflow scupper) on all roofs with parapets or curbs. The secondary system must not be tied to the storm sewer and should drain to a highly visible area. The weight of retained water including that attributed to deflection of the roof because of the load of water below the bottom level of the overflow outlets must be included in the structural calculations. Roof drains, gutters, and downspouts should be equipped with metal strainers to prevent obstructions by debris. Use seamless, one-piece gutters, downspouts, and splash blocks as much as possible.

6.3.3.16 Mechanical Curbs and Penetrations

Every roofing penetration is a potential source of water entry. Roof life can be maximized and roof maintenance lessened by minimizing the amount of rooftop equipment and penetrations. Wherever possible, place building equipment within a penthouse or inside the building. Where possible, combine utilities below the deck.

Where rooftop equipment installation is unavoidable, use supporting frames with round legs of sufficient height above the roof to allow easy maintenance and replacement without alterations. Follow the guidelines provided by the NRCA. Curbs are to be positively attached to the structural deck and located away from low spots in the roof.

Adequate space should be provided among mechanical units, penetrations, and walls so roofing materials can be installed correctly. Locate conduits, pipes, and other utilities at least 12 inches apart where they pass through the roof, unless placed in a properly flashed curb opening. Base flashing should extend a minimum of 8 inches above the roofline. Coordinate all mechanical and electrical penetrations with the architectural roof drawings.

All penetration details require special attention. Every penetration should be addressed and appropriate flashing details specified rather than using typical details. Pitch pans or pockets are not acceptable. Use pipe boots or single-ply membrane flashings in general. Refer to the *NRCA Roofing Manual* and the SMACNA *Architectural Sheet Metal Manual*, or appropriate flashing details.

6.3.3.17 Protection and Maintenance

Provide wear-resistant roof walkways, compatible with the roof membrane material, from points of roof access to penthouse entrances and to all roof-mounted and roof-accessible equipment that requires routine inspection and servicing. Movement of heavy equipment across a roof can cause permanent structural deflections and should be avoided. Specify a crane to place equipment where possible.

6.3.3.18 Reroofing

Design all reroofing projects following the principles stated above. In general, if the insulation is wet or is suspected to be wet, a complete tear-off down to the structural deck is required. Locate and note all rooftop equipment on the plan drawings. Disconnect all equipment, utilities, and curbs, and raise to the proper height. Remove abandoned equipment from the roof.

Each reroofing project is unique. Discuss the design of the reroofing in detail with the SNL/CA Project Lead prior to any design.

6.3.3.19 Openings

- Skylights – Coordinate with the SNL/CA Project Lead.
- Hatches – Coordinate with the SNL/CA Project Lead.

6.3.3.20 Fall Protection

See the requirements in chapter 2 of this manual.

6.3.3.21 Canopies

Coordinate the design and requirements with the SNL/CA Project Lead.

6.3.3.22 Exterior Openings

The design of external openings must respond to the internal functional needs of the building owners and users and also must respond to the guidelines of the SNL/CA campus. The *Campus Design Guidelines* describe high-level principles to consider during design development. Circulation and Interaction, Parking, Safety, Security, Sustainability, Entrances and Approaches, Renovation and Historic Preservation are chapters in the CDG that provide guidance. Internal Destinations and Connections, Safety and Security, Surety (Architectural Surety®), and sustainability are guiding principles in the LRDP that guide the SNL/CA Project Lead and the design team. The location of entrances must relate to pedestrian corridors, public spaces, and parking access. Service entrances must relate to service corridors identified in the Master Plans for zone of the campus. Windows should be oriented toward view corridors, landscape areas, and pedestrian malls when possible. Windows should be oriented to respond to sun and shade, and to promote natural lighting into the building. The selection of materials to be used on all exterior openings must have sustainable characteristics and be energy-efficient.

Exterior entrances and exit ways must provide accessibility, must be designed to be safe, and must follow applicable building codes and life safety codes.

Exterior openings must provide appropriate security depending upon the needs of owners and users. Protect openings in exterior walls and roofs of buildings that are designated as a security area boundary or that are the boundary to an interior vault or vault-type room. Exterior openings larger than 96 square inches in area, larger than 6 inches in the smallest dimension (greater than 11 inches in diameter) require protection. Openings include, but are not limited to, roof hatches, skylights, doors, windows, ducts, crawlways, tunnels and sewers. (See chapter 11 for additional requirements.)

Exterior openings, specifically windows, in older buildings should be replaced with energy-efficient products that retain the aesthetic intent of the original design.

Windows

Design windows to respond to the *High-Performance and Sustainable Buildings Guiding Principles*. The selection of glazing must respond to the energy efficiency of the building in regard to orientation for solar gain and insulation to reduce energy consumption. Design windows to be of stock sizes and competitive design. Use the more economical industrial and energy-efficient types when practical. Select windows to fit masonry coursing and the specified building module.

All windows must be at a minimum of Low-E dual pane glass.

For windows without security grills that are larger than 96 square inches and below 18 feet above ground level, use burglar-resistant glass as one of the two window panes, and put all glazing stops on the inside of the building if acceptable to SNL/CA Project Lead.

> **NOTE** Vaults must be constructed without windows. Closed areas (formerly called vault-type rooms or VTRs) and security area boundaries must be constructed without windows unless absolutely necessary. Security requirements for windows and openings in vaults, closed areas, and security area boundaries are described in Chapter 11 of this manual.

Doors

Aluminum and glass storefront doors (medium- or wide-stile) may be used for main entrances. Other exterior doors are usually flush, hollow metal, minimum 16 gauge in 14-gauge metal frames. Interior doors are usually flush, hollow metal, minimum 18 gauge in 16- or 14-gauge metal frames. Provide vision panels in doors in high-traffic areas and at all doors that swing into common hallways, corridors, or circulation areas. Specify properly labeled UL doors for all fire doors. Solid-core wood doors in hollow metal frames may be used in some administrative areas.

Use heavy-duty steel, roll-up, sectional, and other vertical doors in shops, warehouses, and industrial buildings for equipment and vehicular access. These doors should be weather-stripped in the best manner possible. Give special attention to the attachment and bracing of tracks and guides to ensure proper operation and minimize maintenance. Bolt, rather than weld, all track attachments to the structure to allow for maintenance adjustment. Support doorframes rigidly to prevent cracking of adjacent finishes during normal use. For Security applications, see chapter 11, "Security Design Standards."

Hardware

Ensure that all builder's hardware is utilitarian, economically competitive, and suitable for the required functions. Builder's hardware must also meet handicapped accessibility requirements. Hardware must be of durable grade and consistent with all appropriate SNL/CA standard specifications and the 2013 California Building Code. Avoid using concealed door closers when possible.

Provide an automatic door operator or other form of handicapped accessible assistance at main entrances to new buildings. Exterior door hinges must be either nonremovable or fast-pin. Use fire-rated hardware at all fire-rated door assemblies. Do not use fusible link arms on fire door closers except when permitted by the fire protection engineer. Occasionally fire doors need to be held open, use electromagnetic hold-open devices actuated by the building fire alarm system.

To be compatible with Sandia National Laboratories/California (SNL/CA) master keying system, all locksets must use 6-pin cylinders with 9N keyway. Levels of security are assigned to hardware by the SNL/CA Security Lock and Key Program. Once the levels of security have been assigned to the hardware, keyways must be selected by the SNL/CA locksmith. Pushbutton combination locks must be used for administrative locks only and must include a Best small-format interchangeable core. See SNL/CA Standard Specification 087100, *Door Hardware*, for hardware requirements.

Security-Type Locks

The design of door and hardware systems in security areas must follow guidelines established by SNL/CA Physical Security (see chapter 11). Involve SNL/CA Security Lock and Key service during the early design phase to determine whether any existing door hardware might be considered a security lock. Common applications that require security locks include Closed Areas (CA), Vault-Type Rooms (VTRs), High-Security Buildings (HSB), limited area boundaries, exterior doors, gates, and Internal Distribution Rooms (IDR). Other not-so-common applications that might be considered security locks exist. All security locks and keys must be accounted for at all times by Physical Security and must **not** be removed by any personnel except the Physical Security Locksmith. The hardware designer must provide notes within the construction documents instructing the contractor to contact SNL/CA Security Lock and Key services through the SNL/CA Project Lead before removing any doors that contain security hardware. The importance of proper accountability of security locks and cylinders must be conveyed to the general contractor.

6.3.4 Interiors

6.3.4.1 Partitions

Provide fire-separation walls (occupancy separation type and area separation type) as required by the 2013 California Building Code and the National Fire Protection Association (NFPA) for separation of dissimilar occupancies or hazards, equipment rooms, stairwells, occupancy values, and as required to limit maximum floor areas.

Interior walls and partitions may be composed of materials similar to those used for exterior walls. Interior walls may also be prefabricated and either fire-resistant or noncombustible. Materials used for fire-separation walls must have the required UL-listed fire rating. On the floor plans, identify all walls (rated and nonrated) with a keyed note or a legend. Materials used for vault, closed area, and security area walls must meet the requirements in chapter 11.

Specify that temporary interior construction barriers be covered with Type-X gypsum wallboard and painted to match existing wall surfaces when the barriers are intended to be in place for a significant amount of time, when the barriers are located in a highly visible area, or both.

Observe the following limitations:

- Restrict the use of plaster to areas where the specific operation requires its use.

- Paint masonry walls where required by occupancy; otherwise, leave unfinished. Paint or seal masonry walls in equipment rooms and utility chases.
- Use 5/8-inch-thick Type-X gypsum wallboard throughout, with taped joints. For project-specific requirements, see the Design Criteria or contact the Sandia Designated Representative (SDR).
- Use cementations backer board at all wet service areas.
- To protect the more brittle or destructible wall finishes, provide noncombustible wainscot, corner guards, or both, in areas subject to excessive wear. If acoustic materials are required on the walls, specify those that have a Flame Spread Rating of 25 or less and Smoke Developed Value of 50 or less if available, or use materials approved of by the SNL/CA Project Lead and Fire Marshall
- Where tile finish is required by operations, limit the extent of application as practical. Where tile is used in toilet rooms, wainscot height must be coordinated with the height of wall-mounted fixtures. Tile wainscot in showers must be a minimum of 6 feet 0 inches from the finished floor.
- Take full advantage of modular bay arrangements for movable partition layouts. SNL-furnished movable partitions are usually specified for areas of buildings where periodic rearrangement of space is likely. Movable parts are not normally used as fixed partitions around permanently assigned space except where the quantity of fixed partitions is small compared to the total number of partitions. When movable partitions are used, apply continuous floor and ceiling finishes before partitions are erected.
- Do not use foam plastic materials or foam-filled panels.
- Isolate the mechanical/equipment room from the remainder of the building with sound batts and/or double layers of gypsum board.

6.3.4.2 Fittings

- **Visual Display Boards:** See SNL/CA Standard Specification 125900, *Systems Furniture*.
- **Wall and Corner Guards:** See SNL/CA Standard Specification 092113, *Gypsum Board Assemblies.*
- **Identifying Devices:** See *Sign Standard for Exterior and Interior Signs for requirem*ents.
- **Directories:** See *Sign Standard for Exterior and Interior Signs* for requirements.
- **Interior Signage:** *Sign Standard for Exterior and Interior Signs* for requirements.
- **Toilet Accessories:** See SNL/CA Standard Specification 125900, Systems Furniture , Or 102113, Metal Toilet Compartments,
- **Expansion Joint Cover Assemblies:** Coordinate with the SNL/CA Project Lead.

6.3.4.3 Interior Finishes

Provide finishes that are consistent with the character of the building. Paint or seal masonry walls in equipment rooms and utility chases. Consult with the SNL/CA Project Lead when coordinating a color scheme for the interior colors.

6.3.4.4 Walls

- **Standard:** See SNL/CA Standard Specification 097216, Vinyl Wall Covering and 099100, Painting.
- **Security:** See chapter 11 of this manual.

- **Acoustical:** See SNL/CA Standard Specifications 07200 and 095100.

Use qualified design professionals for acoustic design, particularly in areas with high-sound-pressure levels and areas such as large conference rooms, data processing centers, word processing centers, auditoriums, audio/video studios, program control centers, and secure rooms.

In general, for industrial facilities or other high-sound-level facilities, the principal objectives are to achieve an acoustic environment that is not injurious to the occupants and conducive to work performance and safety in operations. For nonindustrial facilities with lower sound levels, the principal objective is to achieve a balanced acoustic environment for the occupants and the functions to be performed.

Do not provide acoustical treatment in storage areas or other service and support areas.

Give special consideration to utility rooms (mechanical/electrical equipment rooms) or other rooms where operating equipment is located. While such areas might not normally be occupied, high sound levels often exist that can be injurious to operating and maintenance personnel, even with short-duration exposure. Where acoustic treatment is not feasible or would not be adequate, anticipated noise levels and requirements for personal protective equipment (or the need for administrative control to limit employee exposure to safe duration periods) must be identified in advance of equipment operation. For reference, see 29 CFR 1910, *Occupational Safety and Health Standards*, Subpart G, 1910.95, "Occupational Noise Exposure."

6.3.4.5 Floors

Generally, interior floor finishes must be as follows:

- Sealed concrete slabs in shops, equipment rooms, utility chases, warehouses, and other industrial areas
- Vinyl composition tile in laboratories and some office areas
- Carpet tile in office areas where specified
- Raised-access flooring in computer rooms to accommodate cabling flexibility

Specialty flooring such as conductive flooring or sheet vinyl with welded seams.

6.3.4.6 Ceilings

Keep ceiling heights in all buildings to the minimum consistent with operating requirements. Where the use of suspended ceilings is justified, keep floor-to-floor heights, and space above suspended ceilings to the minimum required to accommodate mechanical and other systems. Ceilings are generally 10 feet high in normal laboratory and administrative areas.

Interior ceiling finishes must comply with IBC and the 2013 California Building Code requirements for Class A finishes, except in special instances.

In shops, warehouses, and other industrial buildings, leave the basic structure exposed without a ceiling finish, except to isolate contaminated areas or where justified to facilitate heating, ventilation, sanitation, or reduction of excessive noise levels in specialized areas. Provide economically competitive, suspended ceiling systems with mineral fiber tiles in administrative and laboratory buildings.

6.3.5 Vertical Circulation, Stairs, Ramps, and Conveying Systems

6.3.5.1 Elevators

Ensure elevators conform to the latest version of ASME/ANSI A17.1, *Safety Code for Elevators, Dumbwaiters, Escalators, and Wheelchair Lifts*. All elevators with automatic doors and having a travel distance of more than 25 feet must have firefighter service. Use a qualified elevator consultant to determine the number of passenger elevators, size and capacity, location, types of machinery, and control. Consider the building population, building layout, and traffic patterns. Locate freight or service elevators in proximity to loading docks, shipping and receiving areas, and storage areas. Combination service-passenger elevators for both the movement of equipment, furniture, and limited personnel use may be appropriate for buildings of less than three stories. All elevator controllers must be nonproprietary. Elevator shafts must be of fire-rated construction, rated in accordance with the IBC and the 2013 California Building Code for construction of the building. For buildings taller than two floors, select at least one elevator whose cab size is compatible with a medical gurney and two emergency medical technicians with hand-carried equipment. Equipment and Furniture.

6.3.5.2 Vending Equipment

Coordinate vending machine locations with the SNL/CA Project Lead.

6.3.5.3 Recycling

Coordinate recycling center locations with the SNL/CA Project Lead.

Janitorial

Coordinate equipment and supply space locations with the SNL/CA Project Lead.

6.3.5.4 Furniture

See *SNL/CA Standard Specification 125900.*

6.3.5.5 Fixed Casework

See *SNL/CA Standard Specification 064023 and 123553*.

6.3.5.6 Window Treatments

Coordinate design with the SNL/CA Project Lead.

6.3.5.7 Fixed Floor Grilles and Mats

Provide walk-off mats at building entrances to meet Leadership in Energy and Environmental Design (LEED®) requirements.

6.3.5.8 Fixed Multiple Seating

Coordinate with SNL/CA Project Lead.

6.3.5.9 Movable Furniture and Accessories

See *SNL/CA Standard Specifications 125900*.

6.3.6 Special Construction

6.3.6.1 Pre-engineered Structures

Coordinate design with SNL/CA Project Lead.

6.3.6.2 Selective Demolition

Coordinate with SNL/CA Project Lead.

6.3.7 Room Numbers

The A/E must develop an initial room number scheme as the floor plan is substantially developed. The room number scheme must be finalized during design development. All spaces, including vestibules, alcoves, and secondary hallways or corridors, must receive a separate room number. The room number scheme must be used for construction coordination and adopted to provide the final way finding and room numbering scheme for the facility. Separate room numbering schemes for construction and final room identification for interior signage are not acceptable. The A/E must meet with the SNL/CA Project Lead to review the logic of the proposed room numbering scheme. The room numbering scheme must be used to coordinate final identification of building support and maintenance features, such as panel schedules, communication drops, and mechanical piping, as well as room numbers on interior signage. See *Sign Standard for Exterior and Interior Signs* for standard signage requirements.

6.4 Architectural Calculation Requirements

Required design calculations include, but are not limited to, the following:

- Parking analysis. See the *SNL/CA Campus Design/Development Guidelines* for additional information.
- Code footprint per this manual
- Fixture count per the *2013 California Plumbing Code*
- Perimeter envelope R and U values per IECC-2013, the 2013 California Energy Code and ASHRAE 90.1-2013

6.5 Safety

Design all safety-related building and site conditions to meet the requirements in section 2.16, "Safety Requirements" of this manual and this section. Arrange all building and site egress components including,

but not limited to, doors, stairs, corridors, partitions, gates, and fences to facilitate direct and prompt evacuation through and away from the building in an emergency. All egress components must conform to the applicable requirements of the *2013 California Building Code,* and the 2010 Americans with Disabilities Act and Architectural Barriers Act *Accessibility Guidelines* (ADA and ABAAG).

6.5.1 Fall-Protection Design Requirements for Rooftop Parapets

All rooftop parapets must be 42" minimum above the finished roof surface to the top of the coping cap. Railings, tie-offs, or other means of fall protection must meet current OSHA and project team requirements.

6.5.2 Fall-Protection Design Requirements for Sloping Roofs

For all sloping roofs, fall-protection design must incorporate an engineered solution for tie-offs or railings and must meet current OSHA and project team requirements.

6.5.3 Other Fall-Protection Design Requirements

The design of all new buildings, additions, and renovations must include an engineered solution for skylights, roof-access hatches, roof-access ladders, or roof-access stairs that meets current OSHA and project team requirement

6.6 Accessibility Requirements

Design all new buildings, and all additions and renovations to existing facilities, to be safe and readily accessible to, and usable by, individuals with disabilities. Elements that require consideration include parking (refer to the *Campus Design and Development Guidelines* for quantity requirements), access routes or path of travel, signage, entrances and vestibules, ramps, landings, stairs, doors, restrooms, assembly spaces, water fountains, access control, telephones, elevators, and common-use spaces. Follow the requirements of the *2013 California Building Code,* and the 2010 Americans with Disabilities Act and Architectural Barriers Act *Accessibility Guidelines* (ADA and ABAAG). Buildings and sites at SNL/CA will follow "Part II: ABA Application and Scope," as stated in the preamble: *The ABA covers facilities that are designed, built, altered, or leased with federal funds.* The SNL/CA Project Lead will provide guidance on accessibility issues that require resolution because of interpretations or conflict of the Guidelines. The building design must also allow for safe egress of individuals with disabilities in an emergency. Provide Areas of Rescue Assistance as required by codes, accessibility guidelines, or as designated by the SNL/CA Project Lead.

7.0 Fire Protection Design

7.1 Introduction

Sandia National Laboratories, California (SNL/CA) is committed to protecting workers, the public, the environment, and property from fire and its related hazards through the execution of a comprehensive Corporate Fire Protection Program. SNL/CA shall comply with the fire protection requirements as delineated to the Contractor via DOE Order 420.1C Contractor Requirements Document (CRD) and 10 CFR 851 and the referenced codes and standards therein. Other requirements may be added by Sandia Field Office Manager as the designated Authority Having Jurisdiction (AHJ) as defined in DOE O 420.1C and by the Corporate Fire Marshal. DOE implementation guidance and technical standards referenced in DOE O 420.1C are not mandatory but must be considered in conjunction with specific requirements.

The concepts of Highly Protected Risk and defense-in-depth will be applied in a risked-based approach to comply with contractual requirements, to achieve DOE fire safety objectives and mission success, and to drive continuous improvement. SNL/CA will meet or exceed the minimum requirements established by the National Fire Protection Association (NFPA), model building codes, and DOE Order 420.1C requirements. Alternate methods that satisfy the requirements must be justified to ensure that an adequate level of safety commensurate with identified hazards is achieved, and the method shall be approved by the Authority Having Jurisdiction (AHJ) prior to its implementation.

7.1.1 New Construction and Modifications

Ensure all new construction complies with the national consensus industry standards and the latest editions of the California Code of Regulations (Title 24). In general, where the conflicts exist between the California Codes and DOE design standards, the most restrictive requirements shall apply unless otherwise allowed by the Authorities Having Jurisdiction (AHJ). All facility modifications shall be constructed to meet codes and standards in effect when the design criteria are approved, otherwise known as the Code of Record (COR). Provisions of subsequent editions of codes or standards (promulgated after the COR) will be met to the extent that they are explicitly stated to be applicable to existing facilities. Other provisions of updated codes and standards must be applied to existing facilities when a construction modification takes place or when a potential for immediate risk to life safety or health has been identified.

7.1.2 Highly Protected Risk (HPR) Status

Provide a level of safety sufficient to fulfill the requirements of highly protected risk (HPR). HPR is a rating given to property that qualifies for insurance coverage by industrial insurance companies that limits their insurance underwriting to this best-protected class of risk. This level of safety is established by applying a graded approach and experience in the application of insurance industry standards to determine the appropriate HPR provisions. Refer to the FM Global Property Loss Prevention Datasheets for engineering guidelines.

7.1.3 Fire Hazard Analyses (FHA)

An FHA shall be developed, using a graded approach, for all significant new facilities (as determined by the AHJ), and facilities that represent unique fire safety risks. This includes planned facilities and significant renovations to existing facilities.

In accordance with the graded approach concept, the level of detail in the FHA is directly related to the complexity of the facility and the potential risk to the public and the facility operators.

The FHA process shall begin early in the design phase, be updated whenever significant changes occur within a fire area, and form the basis of the post-construction FHA. The FHA shall also support the conclusions of any Documented Safety Analysis (DSA) and its annual update.

SNL/CA currently does not have any special hazard facilities that require an FHA.

7.1.4 Fire Protection Design

A comprehensive fire protection design for facilities and supporting systems shall be developed, implemented, and maintained (with appropriate oversight by a qualified fire protection engineer (registered and licensed in the State of California) of plans, specifications, and testing of fire protection features) to include:

- Insurance of a reliable and adequate supply of water for fire suppression.
- Noncombustible construction materials for facilities exceeding the size limitations established in DOE-STD-1066-99.
- Complete fire-rated construction and barriers, commensurate with the applicable codes and fire hazards, to isolate hazardous areas and minimize fire spread and loss potential consistent with limits as defined in DOE-STD-1066-99.
- Automatic fire extinguishing systems throughout all significant facilities and in all facilities and areas with potential for loss of safety class systems (other than fire protection systems), significant life safety hazards, unacceptable program interruption, or fire loss potential in excess of limits defined by DOE-STD-1066-99.
- Redundant fire protection systems in areas where safety class systems are vulnerable to fire damage, and no redundant safety capability exists outside of the fire area of interest or the maximum possible fire loss (MPFL) exceeds limits established by the AHJ.
- In new facilities, redundant safety class systems (other than fire protection systems) must be located in separate fire areas.
- A means (e.g., fire alarm or signaling system) to notify emergency responders and building occupants of a fire.
- Emergency egress and illumination for safe facility evacuation in the event of fire as required by applicable codes or fire hazards analysis. Life safety provisions fall within the jurisdiction of 10 CFR Part 851 and DOE O 440.1B. Refer to DOE G 440.1- 8 for additional guidance. Additional or modified exiting requirements for toxic and explosive environments should be as determined by the appropriate authorities defined within the above stated documents. In addition, for explosive environments, exits should reflect the criteria contained in the DOE Explosives Safety Manual (DOE M 440.1-1A).
- Physical access and appropriate equipment that is accessible for effective fire department intervention (e.g., interior standpipe systems in multi-story or large, complex facilities).
- A means to prevent the accidental release of significant quantities of contaminated products of combustion and firefighting water to the environment, such as ventilation control and filter systems, and curbs and dikes. Such features would only be necessary if required by the FHA or DSA in conjunction with other facility or site environmental protection measures.
- A means to address fire and related hazards that are unique to DOE and not addressed by industry codes and standards. Mitigation features may consist of isolation, segregation, or use of special

fire control systems (water mist, clean agent, or other special suppression systems) as determined by the FHA.

- Fire protection systems designed such that their inadvertent operation, inactivation, or failure of structural stability will not result in the loss of vital safety functions or inoperability of safety class systems as determined by the DSA.

7.2 Automatic Sprinklers

In some circumstances, the need for automatic sprinklers should be considered, despite the absence of explicit requirements, such as when the MPFL is below $3 million or other limits imposed by DOE. Some examples of situations where automatic sprinkler system may be warranted are:

- Facilities that contain critical or long procurement time construction items;
- A facility with high public visibility or sensitivity (as defined by the AHJ);
- Electric power transformers with combustible contents that, if damaged, could result in an extended shut-down of the facilities they serve;
- Facilities in which a fire could result in the accidental release of significant quantities of toxic or hazardous materials or emissions (based on engineering analysis);
- Facilities that can be protected by extending automatic fire suppression systems from an adjacent protected facility or area at a low incremental cost;
- Facilities in which a fire could damage more important adjacent facilities;
- Facilities used to store hard to replace or irreplaceable records;
- Facilities where required for protection of human life.

Automatic sprinklers are the preferred fire protection system and are required in the following locations:

- Where required by the latest edition of the California Building Code (CBC) and NFPA codes,
- All structures (including temporary or relocatable) over 5,000 square feet in size,
- In all structures having a MPFL in excess of $3,000,000,
- In all structures where the MPFL will affect a vital program longer than that specified as acceptable by the DOE, and
- In all hazardous (Group H) occupancies.
- In all Lab (Group L) occupancies. Not less than Ordinary Hazard Group 2 with a design area of not less than 3,000 ft^2 will be required.

Automatic fire sprinklers shall be provided throughout the building. All aspects of the design of new automatic fire sprinkler systems including, but not limited to occupancy classification, design density and system type shall be based on requirements from the SNL/CA Standard Specification Section 210000, Fire Suppression, as well as NFPA 13 as amended by the CBC.

The system shall be wet-pipe, unless otherwise specified. Design the system in accordance with SNL/CA Standard Specification Section 210000, Fire Suppression. The sprinkler system may be designed and installed by a licensed sprinkler contractor, or designed by an A/E firm with fire protection expertise and installed by a licensed contractor. The design shall be prepared by a California licensed designer in accordance with State of California requirements.

For new building design, the sprinkler piping system shall be a separate service entrance, and the riser shall contain an outside stem and yoke gate valve, an alarm check valve, plus a reduced-pressure backflow prevention (RPBFP). See Chapter 7.3, Fire Protection Backflow Preventers, for design requirements. Fire riser system and catastrophic drains to the exterior of the building shall be located such that the discharge does not normally flow onto sidewalks, parking areas, and similar areas. The intent is to prevent additional hazards from sudden discharges where people might gather.

Provide a fire department connection for the building in an area accessible for the first response unit from Fire Department. The fire department connection shall be located in close proximity to the main entrance or location of the Fire Alarm Panel, shall be approved by a California licensed designer in accordance with State of California, and shall be reviewed by SNL/CA Fire Protection Engineering. This will allow the first responding fire department apparatus to pull up to the front of the building, check the panel and connect to the Fire Department Connection if necessary.

The fire protection designer shall indicate the entire area to be sprinklered, and those areas that do not require sprinklers in accordance with the California Building Code and NFPA 13 as amended by the CBC. The fire protection designer shall also indicate the following:

- Areas to be sprinklered
- Occupancy classification
- Sprinkler type
- Design density
- RPBFP (including drainage and control valves)
- Water supply main size, location
- Water supply data
- Fire hydrant location and number
- Lead-in size location and number
- Post indicator valve(s) location and number
- Riser location
- Fire department connection location
- Fire department access
- Vehicular barriers
- Exterior flow notification devices
- Standpipes (Design of Standpipes to be in accordance with NFPA 14 as amended by the CBC)

Place the words "Fire Protection" in the title block of the drawing. Develop the drawings in accordance with Facilities SNL/CA Standard Specification Section 210000, Fire Suppression.

For modular designs, arrange sprinklers in a repetitive pattern where possible. The sprinkler layout shall be approved by a California licensed designer in accordance with State of California requirements, and reviewed by the SNL/CA Fire Protection Engineer during Title II.

Seismic protection for automatic sprinkler systems is required for all new systems. Consult with the SNL/CA Fire Protection Engineer regarding modifications to existing systems. The installation guidelines for seismic protection in NFPA 13 shall be used. Where an alternative method (other than NFPA 13) of providing seismic protection of a sprinkler system is to be used, only UL Listed or FM Approved material

shall be permitted. The alternative method shall have a design based on a dynamic seismic analysis certified by a registered Professional Engineer (PE) in the State of California.

Where future expansion is to be considered, sprinkler protection shall also be considered. Include a key plan to scale on the drawing to clearly show this situation. The piping size for planned expansions and additions will be established with the design of the sprinkler system for the immediate project. This guidance shall be provided in the project-specific Design Criteria.

Class I standpipes shall be installed in all structures having three levels or more above or below grade and where specifically required by the CBC.

7.3 Fire Protection Backflow Preventers

Automatic fire sprinkler systems are provided with a cross-connection to the site potable water supply and require the installation of a backflow prevention device to protect the water supply from possible pollution and/or contamination hazards present within the fire sprinkler system.

Backflow prevention devices should be installed inside the facility. The fire sprinkler riser and backflow prevention device shall be located such that sufficient space is provided for testing and maintenance purposes (approximately 60 feet square). The fire sprinkler riser and backflow prevention device may be located in a dedicated riser room or in other suitable spaces (i.e., mechanical equipment rooms or under stairs) to reduce cost.

The A/E shall select the proper type of backflow prevention device based on the California Plumbing Code (CPC), the guidance in this document, and the specific requirements of the local water purveyor. Reduced pressure backflow prevention devices installed inside of a facility require the installation of the Air Gap Drain Assembly to allow for diversion of catastrophic drain from backflow device in the event of its failure. Double check valve devices installed inside and outside of facilities, and reduced pressure devices installed outside of a facility do not require the air gap assemblies.

In some cases, sub-systems of automatic sprinkler systems may be considered to be in the High Hazard category, while the remaining portion of the sprinkler system would fall into the Low Hazard category. For example, these sub-systems may be attached to part of a wet-pipe sprinkler system, and foam-water sprinkler systems. The A/E should select a reduced-pressure backflow prevention device and place at the service entrance for the entire sprinkler system, in lieu of providing one type of backflow prevention device for the sub-system and another at the service entrance.

7.4 Fire Alarm System Design

7.4.1 System Description

Fire alarm signals are sent to the proprietary supervising station located on the Lawrence Livermore National Laboratory (LLNL) campus. This station utilizes a Digital Alarm Communicator Receiver (DACR) to receive alarms from Digital Alarm Communicator Transmitters (DACTs) located in fire alarm control panels. The DACTs communicate to the station DACR over primary/secondary dual telephone lines using Ademco Contact ID communication format. Only the fire alarm control panels specified in SNL/CA Standard Specification Section 280515, Fire Control Panel," shall be installed in SNL/CA facilities.

The A/E shall provide a fire alarm floor plan drawing showing the components listed in 7.4.6 and 7.4.7 to provide guidance to the designer of the fire alarm system shop drawings. The shop drawing design shall be prepared by personnel certified, as a minimum, NICET Fire Alarm Level III and factory trained and certified for the fire alarm system equipment being installed or modified.

7.4.2 References

The current edition of the following SNL/CA Standard Specifications shall be utilized for the design and installation of fire alarm systems.

- Section 210000, Fire Suppression
- Section 280515, Fire Control Panel
- Section 280501, Fire Alarm and Detection System

The latest revision of the following Standard Drawings shall be utilized for the fire alarm design requirements.

- E-0001STD – Standard Symbols List and General Notes
- FA7001STD – Fire Alarm Wiring Diagrams
- FA7002STD – Notification Appliance Wiring Diagrams

7.4.3 Design Criteria for New Installations

All new fire alarm system installations shall be an addressable fire alarm system, a design/build installation performed by a qualified fire alarm installer per the requirements in SNL/CA Standard Specification Section 280501, Fire Alarm and Detection System.

7.4.4 Design Criteria for Modifying Existing Installations

Modifications to an existing conventional fire alarm system shall be designed by the A/E per the design criteria in SNL/CA Standard Specification, Section 280501, Fire Alarm and Detection System as well as the requirements of NFPA 72 as amended by the CBC.

When initiation devices are added to a conventional fire alarm system, the devices shall be divided into zones that allow emergency responders to quickly identify the location and device(s) in alarm. Devices that are located on different floors or in separate wings of a building shall not be placed on the same zone. Manual pull stations and heat detectors can share the same zone; group smoke detectors on the same zone. Multiple duct smoke detectors can be installed on the same zone if they are installed on the same air-handling unit and in the same general area. Each water flow detection device shall have its own zone. Combine valve supervisory switches, including PIV tamper switch that is in the same general area for the same sprinkler riser, on the same zone. Each control panel for miscellaneous systems shall be provided with a dedicated zone.

Modifications to the Signal Line Circuit (SLC) of an intelligent fire alarm system shall be a design/build installation performed by a qualified fire alarm installer for the fire alarm system in service. The requirements of SNL/CA Standard Specification Section 280501, Fire Alarm and Detection System, apply to the design of the system modification.

Minor modifications to existing Notification Appliance Circuits (NAC), such as adding or relocating appliances, shall be designed by the A/E per SNL/CA Standard Specification, Section 280501, Fire Alarm and Detection System for intelligent fire alarm systems; and the requirements in Chapter 7.4.5 "Notification Appliances" of this Design Manual.

7.4.5 Notification Appliances

Provide multi-tone horn and strobe notification appliances throughout the building to comply with NFPA 72 requirements. Do not install horns or bells inside enclosed stairwells. Where an emergency voice alarm system is provided for the use or occupancy of the building, speakers and combination speaker/strobes shall be utilized.

7.4.5.1 Wiring

Notification Appliance Circuits (NAC) shall be wired as NFPA 72 Class B, Style Y. NAC cables shall be terminated only at panels or appliances; splices are not permitted.

7.4.5.2 Multi-tone Horns

The tone for electronic audible appliances is standardized as a bell setting (1560 Hz modulated @ 0.07 seconds On/Repeat) for the SNL/CA site. Locate multi-tone horns on floor plans to provide a minimum of 15 decibels (dBA) above the ambient background noise. In addition to hallways and common areas, provide multi-tone horns inside labs and in the occupant work locations to more effectively notify building occupants. Assume that the output of the multi-tone horn is reduced by 6 dBA as the distance between the appliance and the listener is doubled. Take into consideration the acoustic properties of the materials in the listening space, such as the wall and door construction, when locating audible appliances on floor plans. Where ambient noise levels exceed 105 dBA, provide a strobe in addition to the multi-tone horn. Utilize the values in Table 7-1 for the ambient background noise levels for the different occupancies when locating audible appliances.

Table 7-1 Ambient Background Noise Levels for Different Occupancies

Location	Average Ambient Sound Level (dBA)	Minimum Sound Level (dBA) Required
Office Areas	55	70
Assembly Areas	55	70
Storage Areas	55	70
Computer Rooms	70	85
Labs	70	85
Low and High Bays	70	85
Clean Rooms	70	85
Mechanical Equipment Rooms	90	105

7.4.5.3 Strobes

Provide visual notification appliances in all common areas (e.g., restrooms, conference rooms, break areas, corridors, hallways, stairways, lobbies), open areas with calculated occupant loads of 10 or more occupants, and in locations with a high ambient sound level (e.g., mechanical equipment rooms). Locate strobes per the requirements in NFPA 72.

7.4.5.4 Emergency Responder Multi-tone Horn/Strobe

At the main entrance(s) to the building, provide a weatherproof multitone horn/strobe appliance on the exterior wall of the building that is readily visible to emergency responders and Security patrols for signaling when the building fire alarm system is in an ALARM condition.

7.4.5.5 Zoning

The boundaries of notification appliance circuit zones shall be coincide with building outer walls, building fire or smoke compartment boundaries, floor separations, or other fire safety subdivision. NAC zones may contain any combination of multi-tone horns and strobes. Initially load each NAC zone with appliances that do not exceed 80 percent of the available NAC amperage to permit later addition of notification appliances to the circuit. For NAC appliances powered from the FACP, indicate on the floor plans the NAC output or zone number for each appliance (e.g., NAC1, Z-2). For NAC appliances powered from NAC power supplies, indicate on floor plans the power supply identifier and output number (e.g., PS1-4, PS2-1).

7.4.6 Drawing Requirements – Intelligent Fire Alarm System

For new intelligent fire alarm system designs, the A/E must provide fire alarm floor plans indicating the location of the following equipment:

- Fire Alarm Control Panel
- Fire suppression release panels
- Air-sampling control system panels
- HVAC control equipment/panels requiring interface with fire alarm system for equipment shutdown.
- Smoke removal control panels requiring interface with fire alarm system for equipment activation.
- Fire/smoke dampers requiring interface with fire alarm system.
- Handicapped-accessible phones requiring interface with fire alarm system.
- Fire doors requiring interface with fire alarm system to release (close) doors during an alarm event.
- User equipment requiring interface with the fire alarm system.
- Location of the automatic sprinkler system Post Indicator Valve.

The fire alarm installer will use these drawings to generate shop drawings for the design of a complete fire alarm design/build package.

The A/E shall provide panel schedules indicating the 120 VAC branch circuit supplying power to the FACP.

7.4.7 Drawing Requirements – Conventional Fire Alarm System

For modification to a conventional fire alarm system, provide plans indicating the location of the following equipment:

- Fire Alarm Control Panel
- Annunciators
- Initiation devices
- Notification appliances
- NAC power supplies
- Fire safety function equipment requiring connection to fire alarm system (e.g., magnetic door holders, HVAC fan shutdown equipment, fire/smoke dampers, elevator recall/shutdown).
- Ancillary panels (e.g., air sampling control panels, fire suppression release panels).
- Post Indicator Valves and other equipment located outside building connected to fire alarm system.

Revise the existing floor plans and building riser elementary wiring diagrams as required to reflect the modifications being made to the conventional fire alarm system Initiation Device Circuits (IDCs) and Notification Appliance Circuits (NACs).

Provide panel schedules indicating the 120 VAC branch circuit supplying power to the FACP and NAC power supplies.

Utilize the guidance and requirements in the Facilities CADD Standards Manual and as specified elsewhere in this Design Manual for the preparation of the following drawings to delineate the fire alarm system design.

7.4.8 Calculations

Provide amperage load and voltage drop calculations for each Notification Appliance Circuit. The amperage load for each NAC shall not exceed 80 percent or the rated load to permit later notification appliance additions to the circuit.

In addition battery load calculations shall be provided indicating a minimum capacity of 24 hours of standby time as well as five minutes of alarm time for the fire alarm system components.

7.4.9 Fire Alarm Systems in Temporary Structures

New fire alarm system installations in temporary structures (e.g., mobile offices) with occupants shall utilize an addressable fire alarm control panel designed and installed per the requirements in this Chapter of the Design Manual and the SNL/CA Standard Specification Section 210000, Fire Suppression " For occupied temporary structures that are not physically connected to other similar structures and have an occupant load of less than ten people, provide commercial-grade 120 VAC photoelectric smoke detectors with an audible base, spaced throughout the structure according to the manufacturers recommendations, to notify occupants to evacuate the structure. If the temporary structure(s) are located in close proximity

to a permanent building containing a fire alarm system, install a fire alarm system in the temporary structure(s) and connect to the building fire alarm control panel.

7.4.10 Elevator

Automatic fire sprinklers are not required to be provided in the elevator hoistway, elevator machine room, elevator machinery space, elevator control space or elevator control room when all conditions stipulated under 2013 CBC Section 3006.4.1 are met. These spaces will be provided with smoke detectors that are connected to the fire alarm system, trigger elevator recall (refer to California Code of Regulations Title 8, Division 1, Chapter 4, Subchapter 6, Elevator Safety Orders), and activate occupant notification upon detection of smoke. The fire alarm system is monitored by an approved supervising station. The spaces will be enclosed in fire barriers with a fire resistance rating not less than the required rating of the hoistway enclosure. Signage indicating "NO COMBUSTIBLE STORAGE PERMITTED IN THIS ROOM By Order of the Fire Marshal" shall be permanently displayed in these spaces. Signage letters shall be 1.5-inch minimum height on a contrasting background.

Where elevator hoistways or the elevator machine rooms containing elevator control equipment are protected by automatic sprinklers, elevator shutdown (shunt-trip) shall be provided to disconnect automatically the main line power supply to the affected elevator prior to the application of water.

Note: The designer should coordinate with SNL/CA Facilities Management any maintenance staff the preferences for either fire sprinklers or smoke detection in elevator machinery spaces. Provision of fire sprinklers within these spaces will require a means of activating elevator power shunt-trip. Typical methods of shunt-trip activation permitted by NPFA 72 are provision of heat detectors near fire sprinklers or provision of a zero time-delay waterflow switch. Heat detectors are typically considered a better option as a zero time-delay waterflow switch may be subject to false alarms due to pressure fluctuations in the fire sprinkler water supply. In any case, the designer should, within the constraints of applicable standards, attempt to position smoke detectors (or heat detectors) in locations that are easily accessible for maintenance staff.

7.4.11 Coordination with Sandia

Coordinate through the SNL/CA Project Lead to obtain a fire alarm control panel schedule detailing the system configuration when modifying an existing fire alarm system.

8.0 Mechanical Design

8.1 Introduction

The primary objective of these guidelines is to achieve consistency and accuracy in mechanical facilities engineering design through awareness and standardization. These guidelines are general in nature and shall be supplemented by the applicable codes, standards, and guides referenced in this manual. Specific conditions outlined in the project-specific Design Criteria take precedence over these design guidelines.

For general requirements associated with all phases of the project, see Chapter 2, General Design Standards and Procedures. For individual project requirements see the Design Criteria.

For standard product specifications, refer to the applicable section in the SNL/CA Standard Specifications. Where manufacturers are specifically called out, the purpose is to indicate the desired features and associated level of quality.

As a minimum, all new construction shall conform to the California Building Codes (CBCs). These building code requirements shall be supplemented in a graded manner with additional safety requirements associated with the identified facility hazards. Base design decisions on the lowest life cycle cost of the system.

8.2 Construction Drawings

8.2.1 Drawings Required

To illustrate the scope of a project, an approximate list of the plans and/or drawings required is presented in the Design Criteria for each discipline. Additional drawings may be suggested. Check the Facilities Standard Drawings for applicability to project. Refer to the Facilities CADD Standards Manual for specific CADD standards and processes. The following is a list of plans and/or drawings required for a typical job. (Note: SNL/CA follows the CA Project and Engineering AE CAD Standards for drawings and discipline designators).

1. **Exterior Utilities:** Includes but is not necessarily limited to new and existing yard plans showing district steam, condensate return, exterior chilled water, hot water, cooling tower water, natural gas, fuel oil, special waste disposal system, sanitary waste, etc. Other utilities are listed in Chapter 3.2, Construction Drawings.
2. **Plan and Profile:** Drawings of new site utilities.
3. **Interior Plumbing Layout:** Show domestic hot and cold water, non-potable water, sewer, vents, drains, lab waste and vents, pressure drains, rainwater leader, and storm drains. Use an isometric diagram to show the sewer, vents, drains, and pressure drains. Use a separate isometric diagram to show the domestic hot and cold water. All isometrics to clearly indicate size of lines, line system designations (Hot/Cold, Supply/Return, etc.) and vertical and horizontal runs.
4. **Interior Gas and Process Gas Plan(s):** Show compressed air, nitrogen, natural gas, vacuum, process gases, gas bottle racks, etc. Use a separate Piping Schematic drawing to show all gasses, vent lines, if required, etc.
5. **HVAC Piping Plan(s):** Show heating water, tower water, natural gas, chilled water, condensate drains, or other type of distribution system. In areas where the HVAC piping becomes involved,

or where piping is overlaid on the plan, use above-ceiling and below-ceiling plan(s), and use additional sections, details, or piping schematics for clarification. As stated above where piping becomes involved provide detail elevations in a scale appropriate to clearly show pipe vertical and horizontal configuration.

6. **Process Liquids Plan(s):** Show de-ionized water, process chilled water, process oil systems. In areas where piping becomes involved, or where piping is overlaid on the plan, use additional sections, details, or piping schematics for clarification. Details and/or sections should be displayed in a scale appropriate to clearly show pipe vertical and horizontal configurations.
7. **HVAC and Exhaust Duct Plan(s):** Show all air distribution, exhaust handling equipment, ductwork, hoods, diffusers, fittings drawn to scale and thoroughly dimensioned. Provide isometric and/or sectional details where the layout becomes complex. Provide separate HVAC and Exhaust Duct plans for extensive exhaust systems. For any locations where ductwork or equipment are highly involved provide elevations in a scale appropriate to indicate all horizontal and vertical complexities.
8. **Separate Roof Plan:** Show all roof-mounted equipment, vents, special exhausts, catwalks, etc.
9. **Separate Mechanical Equipment Rooms/yards:** Show elevations of all mechanical equipment in mechanical rooms/yards including piping, ducting, etc., clearly labeled. When appropriate utilize larger scale (1/4 :1) for these elevations.
10. **Flow Diagram:** Schematically shows all heat-transfer processes involved. Show exhaust systems; indicate each source of exhaust, room number, design flow rates, riser flow rates, fan flow rates, control and / or fire dampers, and all other components.
11. **Riser Diagram:** Show all piping and air handling systems in buildings other than single- story buildings. Key each riser to the appropriate plan.
12. **Detail Drawings:** Drawings for the above items, showing sections and details. Do not present details and sections on the plan sheets. Include details of security barriers (mesh or rigid bars) installed in ductwork.
13. **Control Drawings:** Create Control Plans Drawings, Diagrams, Sequence(s) of Operations, Panel Details, Points Lists, Equipment List, and Ladder Diagrams. Group the entire set of controls drawings together in a separate discipline. On plan drawings, show the location of each item of control equipment, a scale of 1/8 inch per foot or smaller is suggested for most areas of buildings to allow better coordination of the various items in the system drawings. Scales of ½ or ¾ inch per foot may be required in congested equipment rooms. Provide schematic diagrams referring to all control functions and actions. The control diagram shall show control components on a flow diagram with the control piping or wiring in heavy gauge lines. In addition, show the associated heat transfer items such as fans, ductwork, dampers, pumps, coils, pipes, and valves, in light gauge lines such that the total system operation can be determined from the diagram. Provide Sequence of Operations that fully describes the operation of all controlled systems in all modes of operation. (See Chapter 8.23, Controls, for further guidance on controls definition.) Create a layout schedule of panel control devices using an Excel spreadsheet as a format. (See FCS Standard drawings for further guidance.) Because the Facilities Control System (FCS) is unique, the required drawings are listed with the system description. Criteria listed above, applicable to the FCS components, will hold. For reference, utilize FCS Standard drawings; See Chapter 8.22.1, Facilities Control Systems, for additional information for FCS. NOTE: Ensure that the spreadsheets indicate all control “points” for all control devices in accordance with SNL/CA standard drawings.

14. **Equipment Symbols and Schedules:** Group these together on a special drawing(s) rather than scattering them throughout the set. Start the equipment schedules in the upper left hand corner of the drawing. Use SNL/CA standard format and symbols. Do not duplicate numbers.

8.2.2 Piping Drawings

Generally, one-line drawings are satisfactory for designating piping. In certain instances where piping is complex and crowded with other piping or equipment, to-scale, two-line drawings are required to ascertain that all items will fit without interference (for example, the rising screw on an outside screw and yoke must have adequate clearance when the valve is open). Provide pipe elevations and/or sections for pipes that cross in the plan view. Per discussion above, if any area is highly involved, provide sufficient elevations/details in a scale appropriate to clearly indicate system piping configuration.

8.2.3 Schedules

Where the same information is repeated several times, provide a complete, well-arranged schedule (for example, traps and coils could be put in one schedule, complete with capacities, pressure drops, temperatures, etc.). Group schedules together on a drawing(s) adjacent to the equipment list sheet(s) rather than scattering them throughout the set of drawings. Use a standard, sequentially numbered symbol for each item. When scheduled items share a common description, a letter can be appended to the symbol number (e.g. 15a, 15b, 15c, etc.)

8.3 Access and Layout

8.3.1 General Requirements

In general, provide approximately 8 percent of the gross area of the building to house mechanical equipment (fans, compressors, chillers, pumps, electric motor control center, etc.). This area will allow for installation and maintenance of equipment. The following guidelines should be followed for the mechanical equipment room:

- The aspect ratio of the room should not exceed 3 to 1
- Indicate tube pulling space for boilers, chillers, and heat exchangers
- Indicate all maintenance area requirements around or above all equipment per supplier requirements
- Verify that equipment can be installed during construction
- Provide access to remove equipment that has a relatively high rate of failure
- Where feasible, do not install piping or ductwork below 7 feet above the finished floor where passage is required.
- Indicate coil removal and filter access space for air handler units.

Locate items needing periodic repair, adjustment, or lubrication where they can be accessed from a standing position. Lay out equipment rooms to allow for 36 inches (or greater if required by equipment supplier specifications) of clear floor and aisle space around all major equipment. Arrange or provide space so tube bundles can be withdrawn or major items of equipment can be replaced without repiping or relocating other equipment. Where necessary, provide areaways and/or removable wall panels for access. Anticipate and eliminate head-bumping or tripping hazards. On the structural drawings, accurately detail

and locate sleeves through walls and floors. Field welding or cutting structural steel is forbidden. Lay out manholes so personnel can exit quickly. Where possible, locate a manhole cover over the ladder.

Size and ventilate workspaces to provide adequate working conditions for maintenance personnel. Clearly state mounting heights for wall-hung items, or provide elevations of crowded walls, particularly where electrical and structural items are also involved. Arrange pipes in pipe space/chases to allow a mechanic to conveniently get into the pipe space and work on a section or part of the piping.

Inform the architectural and structural designers of all ladders, catwalks, access doors, and special structural equipment needed for the proper maintenance of mechanical equipment.

The space above suspended ceilings shall be adequate to run ductwork and piping. Normally allow a 3-foot-minimum clearance from the top of light fixtures to the bottom of structure (concrete or steel beams/girders) for the installation of ductwork and piping.

Provide a minimum 6-foot-edge clearance for roof-mounted equipment unless pipe guardrails are provided.

Provide access doors to gypsum board ceilings and other restricted spaces where mechanical equipment is located. If needed designate where special ceiling support may be required for maintenance around equipment in ceiling interstitial spaces.

8.3.2 Security Requirements

All Security Area and VTR boundaries must have consistent penetration resistance. Openings in the boundary of such areas must be protected to DOE Order requirements. Examples of such openings are heating, ventilating, and air conditioning ducts, air intakes, exhaust fans or ducts; and doors, crawlways, tunneled areaways, and sewers.

Where the mechanical designer is responsible for the design and placement of such items, communicate the information to other responsible consultants who will take the necessary electrical or structural steps to ensure compliance with security requirements. Ensure that these steps have not introduced excessive resistance or other problems into the original design. Recalculate and modify as required. See Chapter 11 for specific requirements.

8.4 Modular Design

Design mechanical systems in the most flexible manner possible, since changing programs and occupants result in changing needs. Do not oversize systems dramatically. Arrange diffusers, registers, sprinkler heads, and other semi-permanent features on the module system for future flexibility of walls and partitions. Contact the SNL/CA systems architect for additional information on the module system.

8.5 Equipment Selection–General

Because the selection of mechanical equipment is involved, provide copies of calculations and standard or actual conditions used for the selection of all mechanical equipment, even when following the manufacturer's procedures. Comply with ASHRAE Std. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, for minimum equipment efficiencies.

A brief but complete description of equipment shall appear on the equipment list drawings. The designer shall locate and describe one manufacturer's model that meets design requirements. Present the manufacturer's complete catalog number and all rating and performance information. Generalities in selection are unacceptable. Provide additional special specifications to equipment schedules to more fully describe complicated equipment. Use performance specifications that will ensure a quality product. Key mechanical item numbers to the plans and elevation drawings.

A partial load schedule, in 10-percent steps, will be established, and the manufacturer's actual performance data shall be listed for all variable-capacity, heat-transfer equipment.

All equipment assemblies requiring line electrical power shall have a local power disconnecting means rated for the service. Refer to paragraph 9.3.5 for requirements.

Whenever mechanical equipment is specified as a complete unit with electrical components such as motors, VFCs, disconnects, lighting and wiring, the associated electrical specifications shall be referenced to insure that these components meet those specifications as well.

8.5.1 Air-Handling Units

Fans and blowers for cooling and heating equipment are generally large-diameter, low-speed, low-horsepower (HP) and capable of maintaining the required system static pressure. Air-foil fan blades are preferred but backward inclined may be acceptable. Select and specify extra-heavy-duty, long-life bearings (minimum 50,000 hours) from standard bearing manufacturer charts provided by the fan manufacturer for the maximum published speed and HP rating of the fan. Select load-limiting (backward curved) wheels whenever practicable. High-velocity systems are discouraged, but if used, select fans that minimize surging and air noise. Present calculations, including temperature, noise levels and altitude corrections. Select fans to operate on a stable portion of the curve. Discourage the use of small-diameter, long shaft fans except in small packaged equipment.

8.5.2 Motors

The minimum energy efficiency requirements for all single-speed, National Electrical Manufacturers Association (NEMA) Design B induction motors having nominal speeds of 1200, 1800, or 3600 rpm with open, drip-proof (ODP), or totally enclosed fan cooled (TEFC) enclosures, 1 HP or more shall comply with the requirements of table 10.2 of ASHRAE 90.1-1999 (matches NEMA Standard MG 1-1998). Motors for driven systems greater than 5 HP that operate for long periods of time (>3600 hours/year) may justify efficiencies which exceed the minimum requirements ("premium efficiency motors") and should be evaluated for simple payback on new or retrofit installations.

Annual savings (S) = 0.746*BHP*$/kWh*annual hours operation* [(100/effA) – (100/effB)], where effB is the efficiency (percent) of the higher efficiency motor.

An electric motor should be considered as always being connected to a driven machine, with specific operating characteristics, which dictate the starting and running load of the motor. As such, the motor selection is based on many factors, including the requirements of the driven equipment, service conditions, motor efficiency, power factor and initial cost. The driven system efficiency is the combination of the efficiencies of all the components of the system, e.g., the fan efficiency, the power transmission (belts), the air distribution system, and the motor controllers (such as Variable-Frequency Controllers [VFCs]).

Provide 3-phase motors for 1 HP and above. Provide across-the-line starters on smaller motors, and reduced voltage, auto-transformer, or other inrush, current-limiting, starter types on motors greater than 25 HP, or where system capacity or mechanical requirements indicate the need on smaller motor applications. Select motors with a sufficient rating for the duty they are to perform and not to exceed their continuous HP rating, including service factor, when the driven equipment is operating at its greatest HP. Coordinate starting and running characteristics with the driven machine and the motor control equipment. Motor enclosures shall be ODP for indoors dry locations and totally enclosed or totally enclosed fan-cooled for outdoor or wet locations, except where special conditions require otherwise.

Single-phase motors 1/8 HP and smaller shall be shaded-pole or permanent split capacitor; those larger than 1/8 HP shall be capacitor-start. Polyphase motors shall comply with NEMA Design B, unless other characteristics are required by the driven machine or the speed controller. Design motors for continuous service at 104°F (40°C) ambient temperature. Motors shall operate at full capacity, with a voltage variation of plus or minus 10 percent of the nameplate voltage. Consider high-efficiency and premium-efficiency motors where loading and continual use may result in significant energy savings.

Consider VFCs where motor speed requirements vary widely during normal operation. Solid-state, variable-frequency units are recommended for smaller HP motors. In all cases, select the motor in accordance with the drive manufacturer's recommendations to ensure a coordinated system and to avoid damage to the motor. In particular, induction motors driven by a VFC shall have provisions for rotor shaft grounding and VFC output filtering so as to prevent bearing fluting from inductive buildup and discharge.

8.5.3 Pumps

Where circulating pumps are used in open systems such as cooling towers, install a suitable straining device (basket-type for base-mounted pumps) in suction lines and provide for easy removal to allow for cleaning. Connect all circulating pumps to the piping system through flexible couplings. Never connect a 90-degree elbow directly to the suction opening of any pump. Nearest elbow from suction or discharge should be at least 6 feet.

8.5.4 Air Filters

Air handlers shall be designed to accept bag type filters. Preferred size for filters is 24 inches x 24 inches x 15 inches deep, and the preferred media is fiberglass. Filter frame assemblies shall be specified such that there will be no leakage around the filters or filter bank. Farr Type 8 front-loading filter frames or Farr 3P Glide/Pack side loading frames, or equal, should be specified. Cartridge filters and slide rack frames are permitted in fan coil units and small roof top air handler units. Filter banks shall be sized for no greater than 500 feet per minute face velocity.

General office area and light lab air handling equipment will use 50 percent efficient bag filters. Process, manufacturing, and special use area filter efficiencies will be determined by the project need. Air filters shall be rated either as Class 1 or Class 2 in accordance with UL900 Standard for Safety Air Filter Units and NFPA 90A.

Use only Class 1 filters in clean room applications. Nuclear Grade HEPA filters shall be listed under UL 586, Standard for Safety Test Performance of High Efficiency Particular Filter Units.

8.5.5 Humidifiers

Avoid humidifiers using a standing water reservoir. Equip all humidifiers with a drain-down, bleed-off, and overflow. Humidifiers supplied with non-potable water shall have a demineralizer tank installed to reduce scale build-up.

8.6 Plumbing Design

8.6.1 Design Conditions

Water main pressure is 60 to 110 pounds per square inch gauge (psig). Maximum water pressure varies depending on the location within the site. Consult with the systems engineer for design water pressures. Natural gas main pressure is 20 psig.

Flush valves shall have a 25-psig-minimum residual pressure; all other fixtures shall have a residual pressure of 15 psig minimum.

Water velocities shall not exceed 10 feet per second.

8.6.2 Potable versus Non-potable Water Connections

Supply Potable Water:

- To all plumbing fixtures except for fixtures located within a fume hood.
- To evaporative coolers and air washers, and provide an air gap between the supply and the flood rim.
- To landscaped (trees, lawns, shrubs, etc.) areas, and provide a vacuum breaker after the last valve (do not install shutoff valves downstream of a vacuum breaker).
- To eyewash and safety showers.
- To dishwashers and ice machines, and provide an air gap.
- To sinks with hose connections, yard hydrants, and hose bibs. Provide with vacuum breakers.

- To fume hoods
- To de-ionizing or de-mineralizing water systems
- To any connections provided in laboratory space for future use.
- To make-up water connections to circulated water systems.

Always consider the use of a distributed Non-Potable Water (NPW) system for multiple users as opposed to a Backflow Preventer (BFP) at each point of use. Make the decision based on life cycle cost and use. Refer to Chapter 7.3, Fire Protection Backflow Preventers, for backflow prevention requirements.

Provide signs at any outlet on a non-potable water system stating: **"Danger – Non-potable Water."**

8.6.3 Calculations Required

Hot and cold water systems:

- Demands in fixture units or gallons per minute
- Pipe sizing
- Shock absorber sizing
- Water heater storage capacity sizing
- Hot water expansion tanks.

For buildings with 50 or more occupants, base the selection of domestic water heaters on an economic balance of the maximum daily demand, the maximum hourly demand, the first cost and operation cost, and the availability and cost of fuel.

Sewer, vents, and drain lines:

- Load capacities (fixture units) to determine sizing
- Absorption rates for drain fields and seepage pits established by actual field percolation tests.

Gas supply system:

- Capacity used to size from tables in International Fuel Gas Code. (See Chapter 3 for exterior gas piping.)

Roof drains and piping:

- Rainfall rates (SNL/CA=2 inches per hour)
- Flow rates
- Pipe sizing.

Backflow Preventers:

- Sizing shall account for the head loss through the device at typical flow rates not to exceed 7.5 feet per second through the device.

8.6.4 Piping Materials and Labeling

Refer to SNL/CA Standard Specification Sections 202000, Basic Mechanical Methods and Materials, and Division 22, Plumbing.

For selection of drainage piping in buildings that use corrosive chemicals, coordinate with the user to determine what corrosive chemicals will be drained, the temperature range of the effluent, and the amount of their dilution. Consult the Sandia Materials group or Environment, Safety, and Health when a possibility exists for a combination of corrosive chemicals to go into drains, and to determine the need for a neutralizing tank as a substitute for, or in addition to, corrosive drainage piping.

SNL/CA Standard Specification Division 22, Plumbing, specifies materials and installation requirements for "Laboratory/Process/Acid Waste and Vent systems that apply to systems so designated on the drawings. While no single material is capable of handling every chemical, the specification is based on either Polypropylene or PVDF with electric fusion joints. These materials are capable of withstanding corrosion from the widest number of chemicals but they may not be satisfactory for all conditions. The mechanical designer shall determine the appropriate material to be used based on the chemicals and their concentration, pressures and temperatures, system life and cost.

Identify piping with self-adhesive labels. Refer to SNL/CA Standard Specification Section 200553, Identification for Piping and Mechanical Equipment.

Indicate any required effluent monitoring requirements that may be needed to ensure discharge meets specified levels re: acidity, Ph, etc.

8.6.5 Plumbing Fixtures

Standard plumbing fixtures (toilets, drinking fountains, sinks, etc.) are listed in SNL/CA Standard Specification Division 22, Plumbing. The designer shall specify special laboratory fixtures to meet customer's requirements. Flushometer valves for urinals and water closets shall be specified as Sloan or Zurn without exceptions.

8.6.6 Backflow Preventers

8.6.6.1 Design Conditions

Backflow prevention (BFP) assemblies are required to prevent cross-connection contamination between potable water systems and non-potable, potentially polluted, or potentially contaminated systems, such as drainage systems, soil lines, and chemical lines.

BFP assemblies are required to be approved by SNL/CA and the Foundation for Cross-Connection Control and Hydraulic Research, University of California, and the International Association of Mechanical and Plumbing Officials.

Keep the number of BFP assemblies to a minimum through connection of non-potables on a common system.

Apply the devices in accordance with the following general guidelines:

- Atmospheric vacuum breakers must be installed on the discharge side of the last shutoff valve and a minimum of 6 inches above the highest overflow level.
- Vacuum breakers must be installed a minimum of 12 inches above the highest piping or outlet downstream of the device and must not be used where backpressure may occur. Discharge pressure should be maintained above 5 psig at all times.
- Double check-valve backflow preventer may be used if there is a possibility of backpressure, or if a low or nontoxic hazard exists.
- Use a reduced-pressure double check valve if there is a possibility of back pressure and a toxic hazard exists.

Installation for the above backflow preventers shall provide the following:

- Positive drain for all discharges to an appropriate point with positive air gaps, as required
- Easy accessibility for testing and maintenance
- In the case of highly toxic effluents provide detection device to indicate/alarm any detected discharge.
- Protection from freezing
- Proper support when necessary

- Provisions for excessive pressure or thermal expansion downstream
- Placement between 12 inches and 60 inches above finished floor level.
- Configure the device to provide protection for high-hazard service with necessary check valve, relief valve, test cock, and isolation valve to conform to all codes having jurisdiction.

Refer to Chapter 7.3, Fire Protection Backflow Preventers, for sprinkler system backflow prevention requirements.

8.6.7 Calculations Required

Sizing shall account for the head loss through the device at typical flow rates not to exceed 7.5 feet per second through the device.

8.6.8 Plumbing–General

Provide building water pressure regulators for any building where the water system pressure is over 80 psig.

Provide building water flow meters for all facilities. Where possible, specify a meter which can report through the FEMS (Facilities Energy Monitoring System) system and provide a communication dataway to the device.

Provide suitable facilities for emergency quick drenching or flushing of the eyes and body in workplaces where occupants may be exposed to injurious, corrosive material. For all installations, involve the occupants' organization's Industrial Hygienist in selecting the type and location(s) for emergency eyewash and shower equipment. Generally, these will be:

- Positioned 100 feet or less from the hazard,
- Located in accessible areas that can be reached in 10 seconds or less,
- Labeled with a highly visible sign, and
- Illuminated with proper lighting (coordinate with electrical designer).

All eyewashes and safety showers shall meet the American National Standards Institute (ANSI) Z358.1 standard requirements. Hand-held drench hoses may provide support for emergency shower and eyewash units, but shall not replace them. Due to the infrequent of use of safety showers, floor drains generally are not required. Showers can be tested with a curtain and bucket. Unless water is supplied directly from outdoors, tempered supply water also is not required. Refer to SNL/CA Standard Specification Division 22, Plumbing.

Water lines with solenoid valves, flush valves, or other quick-closing devices should be fitted with an accessible, valved and sealed shock chamber to absorb water hammer. Lengths of pipe that are capped to form air chambers are unacceptable.

Install wall hydrants 18 inches above grade on each major outside building surface, not to exceed 100 feet apart. Do not cast hydrants into masonry. Incorporate a vacuum breaker at each wall hydrant. Locate hydrants to insure that they will not be subject to freezing.

Do not cast any piping within the structure into concrete, except cast-iron sewers.

For future extension show service piping such as gas, compressed air, and domestic water (where applicable), with plugged tees instead of elbows. Provide isolation valves for ease of isolating sections of piping for future modifications without the need to shut down most of the system.

Plumbing accommodations in government facilities shall conform to 28 Code of Federal Regulation, Part 36, Nondiscrimination on the Basis of Disability by Public Accommodations in Commercial Facilities. See Chapter 6.7, Accessibility Requirements, for further information.

Install a minimum of one floor drain per room in toilet rooms, darkrooms, janitor closets, and equipment rooms. Install adequate floor sinks, wherever needed, to take indirect wastes. Provide steam and valve pits with a French drain, 2 feet in diameter by 5 feet deep, filled with 1/2- to 1-inch clean, graded gravel. Coordinate with the structural drawings to ensure that floors are pitched downward toward all floor drains. Floor drain gratings shall be of heavy-duty construction and made from nonferrous material. Floor drain bodies shall be galvanized. Trapped floor receptacles shall be primed. Do not specify trap primers that rely on pressure fluctuations in the piping to activate the primer. Timed solenoid valves have been the most useful device for priming traps.

Do not connect floor drains to the storm drain system. The design team shall ensure by visual inspection, drawing search, and/or dye testing that plumbing connections are made to appropriate sanitary sewer or process waste piping. Do not make piping connection that would result in the flow of non-storm water to the storm drain system. Storm water is defined as those flows that result from atmospheric precipitation which have not been confined in any way (see SNL/CA Environment, Safety and Health (ES&H) Manual). Consider the use of "water harvesting" for the discharge of roof drains on new facilities. Refer to Chapter 3.6 – Drainage Requirements.

Floor drains in laboratory or research areas with toxic or hazardous chemicals shall drain to a separate liquid effluent capture system and not to the sanitary sewer.

Detail roof drains in cross section and incorporate a suitable removable strainer or gravel guard, seepage pan, and clamping device. Connect the roof drains to the storm drainage system. Insulate roof drain piping in ceiling spaces.

Space sewer cleanouts to grade no further than 50 feet in buildings. Terminate each branch run in a full-size cleanout. Show sewer cleanouts on both the plan and isometric drawings. Locate cleanouts so a power-driven snake can be used without the need to relocate.

Make extensive use of re-venting, where practicable, to minimize roof penetrations. Hubless cast-iron pipe and fittings are acceptable above grade.

8.7 Heating/Cooling/Ventilation and Energy Calculations – General

Heating and cooling load calculations and energy and economic analysis shall be performed using Trane Trace 700 software. Analysis shall be performed early in the conceptual stages of the design to evaluate system size and compare alternatives. The analysis should also be performed for the as-designed conditions reflecting the construction, layout, and system configuration. Analysis of alternatives shall be based on life cycle cost analysis and consider first cost, maintenance, and energy cost as well as the project budget. The latest utility cost shall be obtained from the system engineering organization.

Provide ventilation to all occupied spaces to meet the requirements of ASHRAE Standard 62 ‘Ventilation for Acceptable Indoor Air Quality' latest addendum. Describe in the design analysis the procedures used and the necessary controls to meet the requirements.

Calculations shall be submitted as a part of the Design Analysis that include the following:

- **Narrative** – Describing the type of construction, alternatives analyzed, assumptions for internal loads, airflows, construction, and schedules and supporting documentation.
- **Drawings, sketches and schematics** – Fully describe the zoning layout, system configuration, and construction types as referred to in the program.
- **Reports** – Provide the reports necessary to document the design decisions.
- **Archive Files - FILENAME.TRC** – The project file that contains all the information you entered into the program, including project, weather, room, system, zone, and load parameter information and any Project Templates that you used for entering room information. It also contains the results of the design calculations. LIBRARY.DB (optional) - The library database that contains all the information from the libraries that the program uses (Weather, Schedules, Construction Types, Glass Types, Materials, Internal and Airflow Loads, and Shading), plus all of the Global Templates.

  NOTE You only need to archive this database if your project file uses "custom" library members, e.g. a library member that you created.

Provide calculations to support the ventilation levels the system and individual spaces.

8.8 Heating Design

8.8.1 Design Conditions

Unless otherwise specified in the Design Criteria, use the tabulated weather data tables in the American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE) Fundamentals volume per the following: Laboratory Occupancy 99 percent column, Personnel Comfort 97.5 percent column for outdoor temperatures.

Infiltration, except where exceeded by ventilation, should be taken into account by using the air-change method outlined in the ASHRAE guide. Pressurize all structures to approximately 0.03 inches of water to minimize infiltration, except where noted in the Mechanical Design Criteria. The minimum outside air required to provide ventilation for each zone shall be in accordance with the latest edition of ASHRAE Standard 62. Include an additional air allowance for pickup when sizing boilers and converters. Systems shall not be additionally oversized unless otherwise noted in the Design Criteria.

Do not take credit for the heating contribution of light fixtures when sizing heating equipment for buildings that will be partially occupied during nonworking hours. Full credit will be taken for buildings that are occupied during working hours only.

Use gas fired hot water boilers as the primary source of heat for new and renovated buildings that are not using heat pumps. Provide proper zoning so areas will not overheat as the result of winter sun and/or interior room heat that affects only part of a zone.

Design heating water systems with 180°F maximum supply temperature and a 20-40°F drop.

Provide a design for all piping supports for above- and below-grade mechanical piping. Include in the design the locations of supports, support details, and specifications for piping restraints, piping guides,

expansion loops, and expansion compensation devices. Piping outside shall be designed and constructed to meet ANSI B31.3, Process Piping.

8.8.2 Calculations Required

8.8.2.1 Heating Systems

- Heat loss by rooms, zones, and buildings
- Capacity of the distribution systems
- Heat-generating and heat-transfer equipment
- Hydronic calculations
- Pump sizing
- Fan sizing.
- Thermal expansion of steam, condensate, and hot water piping

8.8.2.2 Fouling Factors

Present calculations to show the effects of fouling factors on either side of heat-exchange surfaces.

8.8.3 Piping Materials

Refer to SNL/CA Standard Specification Section 202000, Basic Mechanical Materials and Methods, Division 22, Plumbing and Division 23, Heating, Ventilation and Air Conditioning.

8.8.4 Heating System – General

Where possible, install local gas fired hydronic heating systems.

Size steel boilers by matching the net Steel Boiler Institute output ratings, corrected for altitude, with the calculated heat loss for the structure. Use net IBR ratings (Institute of Boiler and Radiation Manufacturers on Hydronics Institute) for cast-iron boilers or 30 percent allowance for pickup on other types of boilers and converters.

Boiler selection shall be by life-cycle cost and shall include the significantly different life expectancy and efficiencies of boiler types. Estimates of seasonal efficiency shall consider the effect of type of control, (on/off, high/low/off, fully modulating), number of boilers, and oversizing. Leave spare floor space for future expansion.

Design hydronic systems for 75% to 100% redundancy when designing boilers, chillers, pumps, etc.

Use an outdoor reset water temperature control through the FCS to provide hot water supply temperatures according to outside air conditions without overheating.

In heating water systems, the control scheme shall cause the heating water pumps to operate only when there is a call for heating and to shut down during unoccupied hours, except for buildings or areas where work needs continuous temperature control. See Chapter 8.23, Controls.

Design all large heating water distribution systems that use a two-pipe, reverse-return primary system. In large buildings, give consideration to a primary and secondary system.

For water treatment requirements for heating water systems refer to the Water Treatment section later in this Chapter.

Air vents on exposed hot water lines over 7 feet above the floor shall consist of ¼-inch copper tubing extended down to a petcock located 7 feet above the floor. Vents on hot water lines above ceilings need not extend below the ceiling.

Show flow-limiting devices and isolating valves for each use point. Size the piping so a minimum use of balancing valves will be required. Diverting tees are acceptable, provided the drop in main temperature is taken into account. Make extensive use of insertion test plugs to assist in balancing. Install flow meters or other flow measuring devices to indicate rate of flow in each system and zone. Use flow meters on small systems up to 10 gallons per minute. Use Delta P venturi fittings (less meter) on larger systems. Use a pumped coil for freeze protection on outside air applications.

Give special attention to wind pressure in warm air distribution systems. Incorporate features or zoning so the major portion of air will travel to the upwind side of the structure where it is needed most.

Gas-fired heaters shall have double wall vents and 100-percent stainless steel heat exchangers when 100-percent outdoor makeup air is used. Combustion air is not to be taken from the occupied space. Direct-fired makeup air handler units shall not be used without approval of the systems engineer. Direct-fired makeup units should not be used for makeup air to a chiller plant due to the possibility of vented refrigerant reacting in the gas flame.

Provide electric duct heaters, where required, with a manual and automatic reset, high-limit control, and a differential pressure switch (or other flow sensing device). Stage electric heaters.

8.8.5 Air Emissions Permits

Emission control is governed by the Bay Area Air Quality Management District. Regulation 2, Rule 1 describes the permit requirements for sources of air pollution. In general, any equipment or operation that emits pollutants into the atmosphere requires a Permit to Operate from the District unless it is excluded from District Regulations per Regulation 1 or exempted from District permit requirements by a specific Section of Regulation 2 Rule 1. Any air pollution control equipment, associated with a source that requires a District permit, is also required to have a Permit to Operate from the District. Facilities may use the Permit Exemption Guidance to aid in determining whether a source is required to have a permit or is exempt from permit requirements.

The mechanical designer has the responsibility for determining the need for a Permit from the BAAQMD and assisting the SNL/CA Project Lead with the preparation of a Permit application. The procedures and forms are included in the BAAQMD Engineering Division published Permit Handbook, latest revision.

All boilers less that 12.5 MMBTU/hr. input rating shall meet the requirements of ASME CSD-1, ‘Controls and Safety Devices for Automatically Fired Boilers'. Boilers 12.5 MMBTU/hr. and larger shall meet the requirements of NFPA 85.

8.9 Refrigeration Design

8.9.1 System Selection

Unless specified otherwise in the Design Criteria, analyze all options for providing cooling for new facilities and renovations to existing facilities to determine the option with the lowest life cycle cost. Fully consider impacts to energy efficiency, reliability, flexibility, and maintainability. A number of campus type chilled water distribution systems exist within the tech areas that should be looked at for a source of cooling. The choice of direct expansion (DX) vs. local chilled water should be reviewed with the project lead during the design phase to insure the system meets Sandia's long term needs. In all cases avoid the use of small local DX equipment within a building due to high maintenance requirements.

Connecting to an existing chilled water system is the preferred method for providing cooling if system capacity is available and the distance to run chilled water does not make the life cycle cost unfavorable. Chilled water systems have advantages of higher efficiency, lower maintenance, flexibility to adapt to local cooling loads as facilities are modified, and they can be a source of cooling if a process chilled water system is required. Before connecting to a campus chilled water loop consult with the systems engineer to determine if capacity is available, the type of connection to use, the expected supply water temperature, the temperature difference to design for, and pumping pressure requirements. Supply the systems engineer with annual cooling load profiles and peak design loads for current and future estimated requirements. Most chilled water systems are of the variable flow type requiring VFCs on the pumps and 2-way control valves at the coils. Provide BTU meters for monitoring water flows, heating loads, and cooling loads for each building in multi-building complex sharing chillers and/or boilers.

8.9.2 Design Conditions

For calculating building cooling loads, unless otherwise specified in the Design Criteria, use the tabulated weather data tables in the ASHRAE Fundamental Chapter 27 Climate Design Information. Size cooling towers and air-cooled condensers for the maximum actual conditions to which they are subjected.

Unless otherwise mentioned in the criteria, office space design conditions for personnel comfort shall be 74 to 78°F dry bulb with 50 to 60% RH in summer and 70 to 74°F dry bulb with 20 to 30%RH in winter. Present other indoor temperatures, humidifies and ventilations that are required for process or sensitive equipment in the Design Criteria. Present complete room-by-room and zone-by-zone heat-gain calculations. In general, pressurize all structures to minimize infiltration. All designs shall meet latest CEC Title 24 requirements.

8.9.3 Calculations Required

Heat gain by rooms, zones, and building.

- Capacity of the distribution systems
- Heat-dissipating equipment
- Hydraulic calculations
- Psychometric analysis (trace process on a chart corrected for altitude)
- Compliance within the Code Footprint to the California Building, Mechanical, Plumbing and Fuel Gas Codes for refrigerant quantity limits, as well as any need for a machinery room.

- Calculations for normal and emergency ventilation rates of machinery rooms within the design analysis document.

Provide within the Code footprint compliance with the CBC, CMC, CPC, and CEC for refrigerant quantity limits and any need for a machinery room. Provide calculations for normal and emergency ventilation rates of machinery rooms within the Design Analysis document.

Calculations for sizing chillers and supply-air quantities shall take into consideration both space and building electrical loads. The electrical loads are obtained from the electrical designer, who will determine loading from the electrical drawings and partial loading from the energy schedule in the Design Criteria. Modify the laboratory equipment portion of the full-load quantities to actual loading values by an appropriate diversity factor. Consult SNL/CA Facilities Engineering to determine this factor. The equipment shall not be sized for future additional capacity or redundancy unless indicated in the Design Criteria.

8.9.4 Piping Materials

Refer to SNL/CA Standard Specification Division 23, Heating, Ventilation, and Air Conditioning.

8.9.5 Refrigeration System—General

Show detailed provisions for draining condensed moisture from the cooling coils to a floor drain. Pay special attention to showing how the moisture is collected as it comes off the coil.

For built-up systems, use a control diagram to describe the appropriate safety, temperature, and pressure controls. Each reciprocating compressor shall have a high- and low-pressure cutout, low-oil-pressure cutout, and low-temperature cutout (to prevent freezing of tubes in water chillers). Where capacity reduction is needed at low loads to prevent short cycling, use automatic unloaders and/or properly staged multiple smaller compressors. Where possible, avoid using energy-wasting hot gas bypass designs. Install a time delay to prevent short cycling.

Fit compressors that are 5 hp and greater with an elapsed running time meter.

Heat rejection devices such as air-cooled condensers are preferred, except where size and equipment dictate the use of cooling towers. Select air-cooled condensers at least one size larger than determined by calculations, with corrections for altitude when the condenser is installed on roofs that experience high temperatures. Specify cabinets for air-cooled condensers with the lightest color available from standard manufacture. Specify a minimum ground clearance of 12 inches for condensers over 3 tons installed on grade. Smaller condensers should be installed on concrete pads or rails at least six inches above grade. Specify hail guards for all exposed condenser coils. Unless required by space or cost restrictions, locate air-cooled condensers away from direct sun exposure and where they will be suitable for operation at low ambient conditions. Pay attention to oil return and where equipment must operate in cold weather. Provisions must be made to guard against low-head pressures and backslugging of liquid (low ambient protection). Where short-cycling or capacity reduction can become a problem provide several smaller compressors. To prevent freeze-up and extend the life of the cooling towers, provide a sump tank on cooling towers being used for year-round cooling. Include an automatic condenser water temperature control to maintain optimum refrigeration equipment operating efficiency. Specify cooling towers constructed of fire-resistant materials.

Air-to-air heat pumps are permitted for T-buildings or mobile offices only or to transfer energy within a building.

Design medium to large chilled water systems using either a two-pipe, reverse-return flow, or oversized mains and with a 10-15°F temperature differential. When a primary-secondary system is designed, additional circulators are required on each secondary loop. Consider variable flow systems with variable speed pumping in systems over 100 tons. In constant flow systems, install flow controllers and heat exchange devices (coils, etc.) in each zone. Although balancing valves are generally not necessary in variable flow systems, they can be useful for troubleshooting problems later. Use Bell and Gossett circuit setters on small systems up to 10 gallons per minute. Minimize the use of balancing valves in variable flow systems.

Refer to Chapter 8.28.2 for water treatment requirements for chilled water piping.

Air vents on exposed chilled water lines over 7 feet above the floor shall consist of ¼-inch copper tubing extending down to a petcock located 7 feet above the floor. Vents on chilled water lines above ceilings do not need extending down to below the ceiling.

Specify Air Conditioning and Refrigeration Institute certified water coils. Size coils for 500 feet per minute maximum face velocity.

Two-way water control valves are preferred over three-way valves, except that a minimum number of three-way valves shall be used to provide the minimum flow needed for chillers. Use series and parallel pumps with automatic controls to limit the valve differential head increase to twice the initial head. Systems with lower heads (60 to 70 feet) shall use parallel arrangement. Systems with higher heads shall use a series arrangement.

Wherever possible, include economy cycle provisions in the system.

Choose refrigeration equipment to comply with the minimum coefficient of performance ratings as listed in ASHRAE Standard 90.1. New equipment should be limited to using refrigerants classified A1 or B1 by ASHRAE Standard 34 and either hydro fluorocarbons or hydro chlorofluorocarbons. Typical refrigerants meeting these requirements are R-22, R-123, and R-134a.

Design refrigeration systems to meet the requirements of the California Mechanical Code.

8.10 Refrigeration Machinery Rooms

When a refrigeration machinery room is required design the room to meet the requirements of the CMC and related Sections of the CFC and ASHRAE.

8.10.1 Architectural Requirements

The mechanical designer shall insure that the architectural requirements for a machinery room are met the by the design team. Pay particular attention to the following issues:

- Tight construction to prevent migration of vapors to others parts of the building.
- Tight fitting doors opening outward with self-closing devises if they open into the building.
- Adequate number of exits located to ensure freedom for persons to escape in an emergency.
- Adequate space for equipment access and maintenance

8.10.2 Refrigerant Detection and Alarms

Provide both audio and visual alarms both inside the machinery room and outside each entrance. The horn and strobe shall have a different tone and color than that used for fires.

Provide refrigerant specific detectors for each type of refrigerant used by equipment used in a machinery room.

The detector shall have a means of manual reset. Remote reset is required if the detector is installed outside of the machinery room.

Pay particular attention to the location and number of intake points of sensors needed to detect a refrigerant leak. Locate sensor points 12-18 inches above the floor and in any pits that could be occupied where refrigerant could accumulate. A sensor point may be placed between two systems with the same type of refrigerant. Locate sensor points down stream of the system in the direction of ventilation airflow.

A multi-channel scanning system may be used for multiple systems with the same refrigerant type.

Refrigerant detectors specified with the following:

- Three levels of alarms plus a trouble alarm utilizing individual relays with 240 VAC 5 amp resistive SPDT contacts. Each relay shall be capable of being latched to a manual reset.
- Refrigerant specific sensor technology such as photoacoustic or non-dispersive infrared. Linearity greater than or equal +/- 5 ppm in the 20 to 100 ppm range, or +/- 6% of reading in the 100 to 1000 ppm range.
- A 4-20 ma analog output shall be tied to the FCS.

8.10.3 Ventilation

Provide both normal and emergency ventilation using outdoor supply and exhaust with a system that is independent from the remainder of the building. Normal ventilation air shall be tempered to maintain a temperature between 65-85 degrees F. Emergency ventilation air shall be heated sufficiently to prevent pipes from freezing with the machinery room. Exhaust air shall be discharged to a safe location outside the building. Normal ventilation shall be based on 0.5 CFM per square foot of machinery room area. As long as temperatures are maintained the normal ventilation may be switched by an occupancy sensor such as a light switch or motion detector.

The ductwork shall be arranged with inlets and outlets placed to provide a sweeping of air past equipment with no dead spaces.

Emergency ventilation shall be started by a high level alarm in the refrigerant monitor and also by switches placed outside of each entrance.

8.10.4 Alarm Levels

Alarm levels and responses shall match the following tables:

Table 8-1 Alarm Levels and Responses

Refrigerant	"Caution"	"Alert"	"Alarm"	"Trouble"
R-11	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-22	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-134a	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-500	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-123	30 PPM	40 PPM	50 PPM	Sensor/Controller Fault
R-407c	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault

	Panel Alarm	FCS Alarm Message	Alarm Priority & Action
Alarm Level 1 Contacts	CAUTION	Building ___ Refrigerant Level CAUTION. Level has reached ___ ppm in the equipment room. Leak check the refrigerant system.	Priority 6 alarm (FCS alarm at the building operator's control terminal. Operator Actions: Leak detection, portable gas detector optional, and no respiratory protection required.
Alarm Level 2 Contacts	ALERT	Building ___ Refrigerant Level ALERT. Level has reached ___ ppm in the equipment room. Immediate Attention Is Required.	Critical alarm message to the Steam plant. Ventilation system is automatically started. Operator Actions: Leak detection, portable gas detector optional, and no respiratory protection required. (BUT EQUIPMENT STAGED AND READY FOR USE)
Alarm Level 3 Contacts	ALARM	Building ___ Refrigerant Level ALARM. Level has reached ___ ppm in the equipment room. Immediate Attention Is Required. I.C. emergency response required. DO NOT ENTER THE EQUIPMENT ROOM WITHOUT A SUPPLIED AIR RESPIRATOR.	Alarm light beacons signal need to evacuate. Alarm horn sounds. Critical alarm message to the steam plant. Ventilation system is operating. Operator Actions: Leak Detection, portable gas detector required, supplied air respirator required.
Trouble Contacts	TROUBLE	Building ___ REFRIGERANT MONITOR TROUBLE. Refrigerant monitor is inoperative. Immediate attention is required.	Same priorities and actions as "Caution"

8.11 Exhaust Design

8.11.1 Design Conditions - General Exhaust

Thoroughly exhaust toilet rooms, darkrooms, battery rooms, and other areas that contain noxious, harmful, or objectionable fumes. In the design calculations, indicate the quantity of air exhausted and air made up to the area, balanced so a slight negative pressure exists to prevent exfiltration from the room.

Provide exhaust in restrooms to meet the requirements of ASHRAE 62. Provide exhaust for refrigeration machinery rooms to meet the requirements of the CMC for normal and emergency ventilation rates.

Use sight-proof and nonadjustable door louvers. Use special exhaust grilles and door louvers in darkrooms to prevent passage of light.

8.11.2 Design Conditions - Local Exhaust Ventilation

Local exhaust ventilation (LEV) is preferred over dilution ventilation for controlling hazardous vapors, gases, and particles. The Exhaust Ventilation Program is managed by the Industrial Hygiene (IH) part of ES&H.. Industrial hygienists are SNL/CA are knowledgeable about the operation and conditions of exposure. They are an essential source of information during the design of the LEV system. A SNLCA IH shall be consulted in the planning stages of any new LEV/High-Efficiency Particulate Air (HEPA) filtration system or upon request to modify any existing LEV/HEPA system through the project lead.

Clearly define the source of all exhaust air, and provide clean, tempered air into the space to replace exhaust air. The designer shall select exhaust hoods and controls for each application, and the exhaust system for which the hoods are to be used.

Design hoods, and calculate exhaust requirements based on similar applications found in "Specific Operations" of the latest edition of the American Conference of Governmental Industrial Hygienists' (ACGIH) Industrial Ventilation Manual or SNL/CA's Mechanical Standard Drawings. All LEV designs require an Industrial Hygiene review. LEV systems must be installed per manufacturer instructions, the requirements/guidelines identified in American Industrial Hygiene Association (AIHA)/American National Standards Institute (ANSI) Laboratory Ventilation Z9.5, the ACGIH Industrial Ventilation Manual, and good engineering practices for systems intended for worker health and safety, as defined by Sandia National Laboratories Facilities and Industrial Hygiene.

The location of the fume hood within a space can have an impact on the effectiveness of the exhaust equipment. The mechanical designer shall provide guidance to architectural designers on layout requirements for fume hoods. Locate fume hood faces 10 feet or more from the closest air supply or exhaust point, but not in or along normal traffic routes. A fume hood should not be located where room air currents greater than 50 linear feet per minute will disrupt uniform air entrance at the hood face.

Fume hood face velocity depends on the capture containment requirements of the hazard, room supply air distribution, traffic past the hood, and the amount and location of equipment in the hood. Fume hood full-open-area face velocity settings can be between 80 and 105 feet per minute, depending on the quality of supply air distribution, the level of hazard, and the quality of the fume hood. Generally, a face velocity of 100 feet per minute is satisfactory if the quality of supply air distribution is adequate, traffic past the hood is low, and there is no equipment in the hood closer than 6 inches to the hood's face. Regulated carcinogens and radiological hoods require higher face velocities.

All fume hoods require an airflow indicator: digital face velocity readout with local alarm, a simple vanometer, differential pressure gauge, or a more complex Variable Air Volume (VAV) control system. Coordinate with the SNL/CA project lead to determine which devices to use.

Systems handling particles require that minimum transport velocities be maintained throughout the system. Although systems handling vapors and gases have no minimum duct velocity criteria, duct velocities of 2000-3000 feet per minute usually result in a good balance between initial and operating cost. Use round ducts for exhaust systems whenever possible. Round ducts resist collapse, provide better aerosol transport, seal easier, and use less metal than rectangular ducts.

Provide separate exhaust systems for process exhausting of incompatible hazardous fumes, gases, etc. Specify the type of duct material and coatings to use throughout the system, compatible with the material being exhausted. Consult with Industrial Hygiene when unsure of how chemicals will react.

Calculate exhaust requirements for closed-type glove boxes for 50 cubic feet per minute (minimum) per glove box.

Exhaust vacuum-pump-oil mist to the outside.

HEPA systems used in radiological applications shall be installed per manufacturer instructions, the requirements/guidelines identified in the DOE Nuclear Air Cleaning Handbook DOE-HDBK-1169, and the Code on Nuclear Air and Gas Treatment American Society of Mechanical Engineers ASME AG-1, and good engineering practices for systems intended for worker health and safety, as defined by Sandia National Laboratories Facilities and Industrial Hygiene.

Exhaust system flow schematics shall be prepared for all systems with multiple exhaust hoods. Existing flow schematics shall be modified to reflect all changes made to exhaust systems. Schematics shall indicate each source of exhaust, room number, type of hood, design flow rates, riser flow rates, fan flow rates, dampers, filters, and all other components of the exhaust system.

8.11.3 Exhaust Fans

Calculate the total pressure requirements for sizing exhaust fans. Account for system effect losses, and lay out the supply and exhaust connections to fans to reduce the system effect losses as much as practical.

Roof exhausters for general room exhaust shall be all aluminum, roof-mounted, curb-type, and centrifugal, with an integral weather cover, bird screen, back-draft damper, and roof disconnect. Mount the motor outside the air stream. Direct connection is preferred.

Specify the following operating conditions (altitude = 500 feet) for roof-type exhaust fans:

- Air quantity
- Static pressure
- Motor hp and rpm
- Fan wheel size

Exhaust fans that serve acid, corrosive, or other fume hoods shall be utility-type, and epoxy-coated. Discharge fumes vertically upward at an exit velocity appropriate to exhausted fumes or particles at a location and height sufficient to prevent re-entry of hazardous fumes. Extend exhaust stacks at least 15 feet above roof level or air intakes that are within 50 feet. Exhaust ducts shall end with accepted stackhead designs as recommended in Industrial Ventilation Manual (ACGIH). Final determination of

exhaust stack height shall be based on the ASHRAE Handbook of Fundamentals, "Airflow Around Buildings," to effectively dissipate effluent.

Coordinate design with structural and electrical designers to ensure proper stack support and lightning protection.

8.12 Ductwork Design

8.12.1 Design Conditions

Unless otherwise mentioned in the Design Criteria, design supply ductwork using the static-regain or equal friction method to ensure that design quantities of air will reach final outlets in the system. Examples of static-regain and equal friction system design are outlined in the ASHRAE Handbook of Fundamentals and the Carrier Corporation Design Manual.

Design return-air and exhaust systems in accordance with principles of equal pressure drop. This method ensures that proper air quantities will be returned from even the most remote opening. (Every path of air being removed from a particular area or room shall have the same pressure drop back to the fan inlet.) Coordinate ductwork layout with the structural designer to minimize penetrations through firewalls and fire-rated partitions. At these penetrations, fire and smoke dampers and access doors are required.

Specify that Duct Coordination Drawings be submitted on larger and more complicated system as per Standard Construction Specification 233113 "Metal Ducts" , or 233114, Special Ductwork Systems, Section 1.03, 'Submittals', when the design drawings cannot adequately show all the possible interferences.

Consider the requirement for a return air fan when return duct resistance exceeds 0.25 inches of water.

Duct run distances shall be as short as possible. Size the runs on the critical pressure path for minimum practical pressure.

Select diffusers for their ability to quickly mix supply air with room air introducing a maximum of supply air with a minimum throw. Ensure that airflow does not short circuit from the supply diffuser to the return-air openings. Avoid using combination air supply and return diffusers.

During design, select the throw from each diffuser so the throw is 90 percent of the distance from the diffuser, at 100 FPM, to the nearest wall or other obstruction. In the case of diffusers with a downward vertical air pattern, select the throw to terminate above breathing level.

Provide means for balancing the air systems. Devices shall include but are not limited to dampers, flow measuring stations, temperature and pressure test connections, gauges, and flow sensors. Provide permanently installed devices on major equipment. Air monitoring devices shall be multi-point devices that can continuously measure total and static pressure.

Coordinate ductwork layout with Physical Security to minimize the number and size of ductwork penetrations through vaults, vault-type rooms and designated security areas. The penetrations larger than 96 square inches in diameter and larger than 6 inches in the smallest dimension (greater than 11 inches in diameter) require barriers or alarms. (See Chapter 11 for security barrier requirements).

Identify any ducting where velocities will exceed “2,200” fpm due to duct space limitations/configurations.

8.12.2 Calculations Required

Present calculations for the design of all air-handling duct systems:

- Duct sizing
- Fan sizing
- Size dampers that admit outside air by pressure drop, rather than face velocity. Calculate the largest drop from a return air register, then make the damper drop an equal value
- Noise criteria (noise criteria curves).

8.12.3 Ductwork-General

Refer to SNL/CA Standard Specification Division 23, Heating, Ventilating, and Air Conditioning, for sheet metal gauges, materials, equipment, and methods to be used, and the construction of ductwork.

Draw ductwork to scale (single-line diagrams are not acceptable). Thoroughly dimension the drawings. Clearly show register size, equipment list number, cubic feet per minute, pressure drop, and throw. Show all turning vanes in elbows, transitions, duct liners, and air proportioning vanes. Show the detail of all security barriers installed at vault, vault-type room and security area boundaries.

Diffuser size, cubic feet per minute, and throw should appear on plan drawings for each type and size of diffuser. Refer to diffusers with volume controls affixed to the upstream side as registers. A diffuser or return-air device with no volume control may be referred to as a grille. Identify noise criteria ratings in equipment lists.

Install access covers on both sides of heat-exchange devices in ducts. Ensure adequacy for complete cleaning and servicing.

A plenum ceiling return may be used where feasible.

Install fire dampers in all ductwork passing through firewalls, between floors, and where dictated by code requirements. Provide all fire dampers with standard commercial and catalog-listed access doors. For duct areas smaller than 1 sq. ft. provide a removable section of duct to fully access the fire damper.

Install security barriers in all ductwork greater than 96 square inches passing through security area boundaries. Inspection ports shall be installed for future audit verification of security barrier installations. See Chapter 11 for security barrier requirements.

List the required duct pressure classification required for each duct segment on the schematic drawings. Unless otherwise stated on the drawings, Division 23, Heating, Ventilating, and Air Conditioning, will require the following pressure classifications:

- From the fan to the VAV box – 4" w.g. positive
- Downstream of the VAV box – 1" w.g. positive
- Return air – 1" w.g. positive or negative
- Lab exhaust – 4" w.g. negative
- Restroom and general exhaust – 2" w.g. negative

For pressures less than negative 4" w.g. or greater than positive 10" w.g., and for highly corrosive exhaust, ductwork shall be constructed to SMACNA Round Industrial Duct Construction Standards of

SMACNA Rectangular Duct Construction Standards. In these situations the designer is required to specify other operating criteria for the contractor to use in applying the standard such as materials, joint type, exterior loads, maintenance loads, corrosive environment.

Provide duct support details for ducts located on the exterior of the building and for all equipment.

Fire and smoke dampers shall be specified for "Dynamic Closure" in a fire event to shut off against airflow at a minimum of 2375 FPM and 4 in. w.g. for horizontal or vertical flow.

For large and more complicated jobs, the designer, in accordance with Division 23, Heating, Ventilating, and Air Conditioning, may request shop drawings, duct reinforcement information, and hanger details. This additional information must be requested through the submittal list.

8.13 Compressed-Air System Design

8.13.1 Design Conditions

Normal Shop and Controls – Pressure: 125 psig.

Laboratory and Special Use – Determine the pressure based on equipment requirements.

8.13.2 Calculations Required

Capacity and pressure drops

Storage capacity

Percent of running time for the compressor selected.

8.13.3 Piping Materials

Refer to SNL/CA Standard Specification Section 221500, General Service Compressed-Air Systems.

8.13.4 Equipment

For normal shop and control air applications, the compressor shall be a two-stage, air-cooled, pressure-lubricated, motor-driven, tank-mounted unit. For units above 15 hpa separate vertical air receiver is preferred. The compressor shall be capable of delivering rated cubic feet per minute of free air at the design altitude. Laboratory applications may require clean, dry compressed air from oil free rotary screw or rotary lobe compressors or oil lubricated rotary compressors with high efficiency oil removal filters and dryers.

The receiver shall be ASME National Board registered, rated, and certified, and stamped for 200-psig working pressure. In extended distribution systems, show auxiliary receivers at remote points. Receiver tanks between 18 and 36 inches in diameter shall have two 4- by 6-inch handholes at each end of the shell. Tanks over 36 inches in diameter shall have a 12- by 16-inch manhole. Install air receivers so all drains, handholes, and manholes are easily accessible. Show details of tank support.

Install ASME-approved relief valves, preferably on the receiver or at the output of the compressor. Set for the rated working pressure of the most vulnerable portion of the system. These relief valves shall be 3/4-

inch National Pipe Thread or larger and have an outside lifting lever. Relieving capacity shall be larger than the compressor displacement.

Systems 5 hp and greater shall be provided with an elapsed-run time meter.

When two or more compressors are installed, design shall include a means to efficiently operate the compressed air system.

Gauges on receivers shall have a range equal to 1-1/2 times the safety valve setting.

8.13.5 Compressed-Air System-General

Size the distribution system to provide extra storage capacity at times of maximum demand and to provide for possible future expansion of the system. Show valved drip legs at low points in the system.

Install a refrigerant air dryer for air compressors 5 hp and greater. If available year-round, run chilled water through an after-cooler. If chilled water is not available, use a self-contained refrigerant dryer. Use a float trap to remove any condensed material above a drip leg before the material enters the receiver. Drain the low point in the receiver with a timer operated solenoid valve

The first 4 feet of service line from the tank of a tank-mounted air compressor shall be reinforced braided flex connections.

Wherever possible, large air compressors should take their air from outside the building through a suitable oil filter.

Consider requirements for redundancy of compressors, dryers, and filters depending on use.

8.14 Pressure Systems

8.14.1 General

Sandia defines a pressure system as an assembly of pressure-containing components typically consisting of pressure vessels, piping, valves, pumps, instruments, etc., which are capable of maintaining fluid (liquid or solid) at a pressure different than atmospheric. This definition is intentionally broad to include the variety of systems with both positive pressures and vacuums that can present hazards to individuals and facilities.

The Sandia facilities organization is responsible for designing a wide variety of pressure systems that ultimately are owned, operated, and maintained by either the facilities organization or a line organization.

In an effort to provide a safe environment for pressure related applications Sandia has instituted a Pressure Safety Program that contains policies for all designers, installers, and operators of pressure systems. The mechanical designer of a pressure system is responsible for meeting the requirements of the Pressure Safety Program as contained in the Pressure Safety Manual. The program and manual are located at psi.sandia.gov:

8.14.2 Minimizing Risk and Exposure

The design shall consider the following techniques to achieve minimal risk and exposure to the hazards of pressure systems:

1. Identify all hazards and consequences.
2. Minimize pressure and volume.
3. Use recognized standards.
4. Design conservatively
5. Carefully consider alarm, emergency relief, etc., approach used in design
6. Use materials with predictably safe failure modes. Brittle materials sometimes fail unpredictably.
7. Demonstrate structural integrity by overpressure test.
8. Operate within the original design intent.
9. Provide backup protection.
10. Use proven hardware.
11. Use protective shields.
12. Use tiedowns.
13. Go "remote."

8.14.3 Pressure Limitations

The mechanical designer shall review the pressure limitations of all components and their relationship to the following levels of pressure:

- System Operating Pressure
- Set Pressure and Opening Range of Relief Devices
- Maximum Allowable Working Pressure (MAWP)
- Overpressure Test Pressure
- Predicted Failure Pressure

Sandia Facilities Standard Construction Specifications have been developed to meet the requirements of the Pressure Safety Program for their intended systems. The designs shall consider the limitations of each standard specification before selecting it to use for a new system or modifications to an existing system. When any new system will operate outside the range of the standard specifications the designer shall either modify the standard specifications or create a new specification that incorporates all of the requirements and intent of the Pressure Safety Program.

8.14.4 Data Package

A data package is required for all pressure systems. It contains information on the system description/hazards and contains ratings, materials of construction, and documents the configuration of the system. For most facilities owned systems the requirements of the data package are contained in the facilities drawings, specifications, and component submittals and no additional effort is required to prepare the package. For systems owned by a line organization the designer shall assist the owner in preparing the data package by forwarding drawings, specifications, and submittals to the project lead upon completion of the project.

8.15 Special Gases

See the Design Criteria for design conditions and required calculation.

All compressed-gas cylinder valve outlet and inlet connections shall conform to the standard of the Compressed Gas Association Standard V-1.

Provide gas cylinder wall racks for gas cylinders at all manifold and storage locations.

Flammable gases shall be separated from oxidizers and in exterior fire sprinklered flammable gas enclosures. Toxic gases shall be in ventilated and sprinklered cabinets. Toxic and flammable gases shall have vent piping to above the roof level connected to the manifolds and to experimental use points inside.

8.16 Pressure Vessels

8.16.1 Design Conditions

All vessels shall conform to the ASME Code, including Section VIII, Division I. All vessels shall be ASME National Board certified, registered, and stamped, and meet the impact requirements of UG-84 with no exceptions. Include the requirement for ASME Form U-1A, Manufacturer's Data Report for Pressure Vessels, in the list of required descriptive submittals. Pressure vessels shall be fully described in the equipment list. Include the statement, "No ASTM A-515, ASME SA-515-type steel will be used in the fabrication of this vessel," in the description and specifications.

8.16.2 Calculations Required

Present calculations on the sizing of all portions of the pressure vessels, including connections and fasteners.

8.16.3 Pressure Vessel–General

The pressure vessel detail drawing shall show all construction and installation dimensions and sizes. Provide a 2-inch plugged opening in the center of the head at each end of vessels under 18 inches in diameter. Use openings for inspection purposes only. Locate inspection openings for clear access. Maintain at least a 24-inch clearance in front of all access holes. Pressure vessels between 18 and 36 inches in diameter will have two 4- by 6-inch handholes at each end of the shell. Tanks over 36 inches in diameter will have a 12- by 16-inch manhole. Show the tank support structure on the pressure vessel detail.

Provide suitable taps for a thermometer well, a pressure gauge, and a relief valve in addition to taps required for service connections. Provide a 3/4-inch minimum tap at the low point to facilitate complete gravity drainage of the vessel. Details of the tank shall show locations and sizes of all openings.

8.16.4 Above-Ground Storage Tanks for Flammable and Combustible Liquids

Above-ground storage tanks for flammable and combustible liquids shall be installed in accordance with the California Building Code (CBC), the California Fire Code (CFC) and NFPA 30. All plans concerning

the installation or use of above ground storage tanks shall be submitted to SNL/CA Fire Protection Engineering for review prior to installation.

8.17 Relief Valves

8.17.1 Design Conditions

Without exception, size the relief valve(s) to relieve the unregulated capacity of the PRV, burner, pump, and compressor or prime mover, with no more pressure accumulation than the appropriate code recommends. Factory set the PRVs at the pressure rating of the piece of equipment having the lowest working pressure for that section of the system. All relief valves shall be 3/4-inch minimum pipe size and have an external lifting lever if appropriate. Size relief valves, and fittings leading to them, for full flow and highest pressure of system. Set the temperature and pressure relief valve on domestic hot water systems for 125 psig and 210°F.

Because the unregulated capacity of devices manufactured by different companies may vary, do not call out the size of the relief valves on the drawings unless it is known beyond doubt (that is, existing installed equipment or SNL/CA-furnished equipment).

From the manufacturer's regularly published ratings, report the unregulated capacity for a given device as unregulated capacity. The highest ratings shown in standard capacity tables are usually not unregulated and shall not be treated as such. Where the issue is in doubt, a letter from the manufacturer (not the local agent) is required.

8.17.2 Calculations Required

Present relief valve calculations to show the maximum amount of medium in question to be released.

8.17.3 Relief Valves—General

Provide each compressed air, compressed-gas, hot water, or hydraulic system with ASME National Board certified, registered, and stamped relief valves. Pipe liquid effluent from liquid relief valves to the nearest floor drain or floor sink through an air gap two pipe diameters of the supply inlet, but in no case less than 1 inch. Ensure that relief valves are not obstructed or prevented from discharging by other equipment.

8.18 Standby Equipment

Only when indicated in the Design Criteria (which defines design requirements for the specific project), install tower, chilled, and heating water pumps in pairs with suitable valving so one pump can be turned on within minutes while the other pump is taken off-line for repairs.

8.19 Bird Screens

Provide all exterior building mechanical and equipment penetrations with a 1/2-inch-mesh, galvanized bird screen. Provide insect screens to areas that handle food, service equipment, or do not have filters to stop insects. Locate screens so they can be easily changed or cleaned.

8.20 Equipment on Roof

It is preferable to locate air intakes and exhausts on roofs and orient them to minimize adverse wind effects. All outside intakes should be at least the distance required by current codes and ASHRAE from flues, sewer vents, and exhausts. Where air intakes or exhausts are located on walls or less than 2 feet above the roof peak, prepare detailed wind-pressure calculations and show the discharge of air at the various wind velocities. Thoroughly detail stacks and vents to show flashing and counter flashing.

If a curb other than those shown on standard detail drawings is used, then curb details shall appear on the architectural sheets. Set up items not suitable for curb mounting at a minimum of 18 inches above the roof surface on an angle-iron or designed steel stand with steel-pipe legs (per architectural standard drawings) so reroofing can be done under them. Extend the stand's legs to the structural members and flash with flexible pipe boots or single-ply flashings where appropriate.

Provide walkway pads on the roof leading from the access door to mechanical equipment that requires regular service. Whenever mechanical equipment is roof-mounted, call out permanent access ladders or other roof access leading to the roof, except where security measures dictate otherwise. Locate water-using equipment so

- Over-spray will not be a problem
- Equipment can be readily drained, will not freeze up, and can be easily worked on
- No short-circuiting of air will occur.

Provide at least a 6-foot clearance between roof-mounted equipment and the edge of the roof, or provide suitable pipe-rail guards. In addition ensure that adequate space above, below and adjacent to equipment is adequate for maintenance and parts removal.

The mechanical designer is responsible for transmitting accurate information concerning size, weight, and dynamic loadings associated with roof-mounted mechanical equipment to the structural designer.

8.21 Instrumentation

Drawings shall indicate self-sealing test plugs, pressure gauges, thermometers, flowmeters, draft gauges, thermometer wells, and other instrumentation so equipment performance can be evaluated without shutting the equipment down or resorting to portable instrumentation when installing necessary instruments. Instruments shall measure temperatures and pressure drops in and out of heat-exchange devices using in-line installed self-sealing test plugs. In addition, install a diaphragm-actuated, dial-type gauge to measure (in inches of water) the drop across all filter banks and fans, with the possible exception of fans in small packaged units. Supply outdoor units with weather shields. Use bimetal dial type thermometers for mounting in thermowells in the piping. Mount remote-bulb thermometers on a centrally located panel together with remote-bulb or sensing controllers. Show instrumentation on the flow schematics and details.

Remote monitoring and alarm instrumentation is done by an FCS. See Chapter 8.22.1, Facilities Control Systems.

8.22 Controls

8.22.1 Facilities Control Systems (FCS)

SNL/CA uses a Siemens APOGEE System FCS with direct digital control, to monitor and control HVAC systems in the buildings. This FCS shall be included in the design of all facilities greater than 10,000 square feet, unless otherwise specified by SNL/CA. Because of the unique design of this control system, all of the information pertaining to this system is provided below.

8.22.1.1 Specifications and Design Guidelines

The mechanical engineer issues the control discipline specifications. The following documents should be obtained before starting the control design:

- Project – Specific Design Criteria
- SNL/CA Standard Specifications
- SNL/CA Standard Drawings Monitoring
- SNL/CA Standards Document division 23 Section 230900 Instrumentation and Controls for HVAC
- SNL/CA Standards Document division 23 Section 230800 Commissioning HVAC Systems

HVAC systems are monitored by a system of digital and analog sensors located throughout equipment rooms and at selected locations in the building. The sensors are connected through a system of conduits and wires to field interface devices (FIDs). Critical alarm conditions are also reported at the existing reader/printer in the Central Steam Plant, which is continuously monitored. These alarm points are selected by Facilities Systems Engineering with input from Facilities Operations and Maintenance.

8.22.1.2 Control

Control of HVAC systems is by start-stop functions and direct digital control (DDC) generated by the FIDs and host computer, unless the HVAC application (for example, fan coil unit) warrants conventional electronic controllers. Analog output control signals will be programmed into the FIDs and connected to the various damper operators, valve operators, motor starters, etc., by a system of conduit and wires. Drawings shall contain complete sequences of control for each system (cooling, heating, exhaust, domestic hot water, smoke removal, solar, etc.). The relay contacts in the FIDs are rated at 5 amps at 250 VAC. Smoke detectors and freeze-stats should be hard wired to fan motors.

8.22.1.3 Smoke Removal and Fire Functions

The FCS does not respond to smoke, fire, or sprinkler water flow alarms unless the sequence of operations designates that a unit, such as a supply fan, which is already controlled by the FCS, change its mode of operation. When this is a requirement, provide a contact closure from the Fire Alarm Control Panel (FACP) or Signal Line Circuit (SLC) control module that alerts the FID to the situation. If additional requirements must be met, such as starting smoke removal fans (functions that are not controlled by the FID), then these requirements will have to be accomplished by other control means, such as a relay that operates off an FACP or SLC control module contact.

When packaged air handler units are provided with smoke detectors, the detectors shall meet the requirements of Standard Specification 280501, Fire Alarm and Detection System (MXL System).

8.22.1.4 System Definition and Presentation

The following drawings are required to define and illustrate the monitoring and control systems described above. Sample drawings of each type are available upon request from FCS Office, Mechanical Systems Engineering Department, and may be used to illustrate the desired format, symbols, etc. The samples shall not be considered as standards and reused as such. The only formats that should be regarded as standard are the FID layout drawing and the point numbering scheme, both of which are available from the FCS Office. The mechanical engineer shall develop a full set to be used in construction.

8.22.1.5 Flow Diagram and Sequence of Operation Sheets

Develop these drawings in two phases. The first submission shall provide the flow diagram of the intended system configuration, the proposed sequence of operation, and the DDC point selection. This set defines the base system for approval. After this basic approach has been accepted, then the monitoring and alarm points will be selected by Facilities Engineering. After the complete point selection is accepted, the remaining FCS drawings will be developed.

8.22.1.6 Field Interface Devices Layout Sheets

These drawings illustrate the layout and termination of input and output field connections in the FID cabinets. Twenty-five percent capacity of each point type shall be reserved in the panels.

8.22.1.7 Point List and Definition Sheets: Input/Output (I/O) Summary

These drawings provide a compilation of the total points selected and show point nameplate data, reference drawings, device symbol and number, and device range (established by the designer).

8.22.1.8 Component Location Plan

These floor plans shall locate all components in a system (for example, FIDs, sensors, actuators for dampers, valves, motor starters, etc.) and the conduit that interconnect the items. A scale of 1/8 inch per foot or smaller is suggested to allow better coordination of the various items in the system. Keep all FID cabinets a minimum of 5 feet (1.5 meters) away from power sources greater than 100 kVA and any Variable Frequency Controllers.

8.22.1.9 Conduit Schedules

These sheets present the coordination of the wires contained in conduits between sensors and FIDs.

8.22.1.10 Control Ladder Diagrams

Provide ladder diagrams for each piece of equipment energized/de-energized by the FCS.

8.22.1.11 Equipment List

These drawings list only the equipment or components peculiar to the control discipline. Identify the items in a similar manner as other items but with a number enclosed in a diamond. Include the full specifications for ordering. Specify sensors that are totally compatible with the Landis and Siemens System and that are field-calibratable. There are, however, many vendor sources to provide competition for bidding. An approved and recommended sample listing of products and sensors of high reliability and performance, that still ensures competitive selection, can be obtained from the Facilities FCS Department. All components provided for the FCS system not on the qualified and approved sample listing will require submittal and approval.

The intent of the design procedures just presented is to develop a complete set of contract documents so the contractor will furnish and install all approved sensors, conduit and wire, electric or pneumatic damper and valve operators, and tubing field locations to the FID panels. The contractor installs the FID cabinets and internal components and connects the wiring and pneumatic tubing. Refer to Chapter 9.0, Electrical Design.

SNL/CA furnishes the following:

- FID cabinets and all internal Siemens Apogee components only, and instructions on how to terminate the wires and tubing. Controls Contractor will install the majority of the internal components.
- All required programming and loading at points listed in the I/O summary into the host computer to implement the sequence of operation delineated on the drawings
- Downloading of programs into the FID and assisting the contractor with commissioning of the complete monitoring and controls system for the building.

8.22.2 Pneumatic, Electric, Electronic Controls

The use of pneumatic controls shall be avoided on future projects whenever other types of controls are available to perform satisfactorily and safely.

Thoroughly detail temperature, humidity, pressure change, action, and type of each controller. Where pneumatic systems are used, consider the entire effective range on industrial controllers.

Completely describe the step-by-step sequence of operation for each device in the control system (whether electric, electronic, or pneumatic) on the drawings, rather than in the specifications. Show the pneumatic pressures for both ends of the throttling range that correspond to temperatures on the drawings. In every instance, specify a pressure gauge at each unit of a pneumatic system. No air gauges are required where thermostats are flush-mounted with concealed connecting tubing.

Where FCS does not provide the control function, set up the control system around electronic or direct digital controllers that can be provided by a single supplier, and identify each item of equipment with the current product number. On the mechanical equipment list, show those items with an electrical connection. Provide a device description, range, set point, differential, contact rating, product number, etc., on the equipment list submittals.

Equip pneumatic control systems with an automatic refrigeration air dryer, a compressed air prefilter, and an oil coalescing filter installed in the system's supply line to ensure dry and clean control air. Provide an automatic low-limit bypass to bypass air around the dryer in the event of a freeze-up.

Do not install pneumatic controls outside or in other unheated locations. Use electric actuators wherever control equipment may be exposed to sub-freezing weather.

Designs for building additions should be compatible with the original building system.

Where FCS sensing and control is not utilized, use a combination heating/cooling thermostat in preference to separate heating and cooling thermostats in a given area. Use 7-day programmable auto-changeover thermostats wherever possible.

In addition to detailed wiring diagrams that may appear on the electrical drawings, include a functional diagram on the mechanical drawings for all systems to show the entire sequence and general scheme of operation and all set points. Superimpose the functional diagram on a flow diagram of the heat transfer process.

See Chapter 8.23.1 for Facilities Control Systems requirements. Where FCS does not provide the control function, see Chapter 9.7, Control System Design, for the control drawings required on electrical control systems.

Size control valves with consideration to operate at system pressures and with flow and pressure drop clearly indicated.

Refer to SNL/CA Standard Specification Section 13943, Facilities Control Systems, for additional information.

8.22.3 Controls for Non-FCS Buildings

Install the following special controls for energy conservation in small-sized buildings (less than 10,000 square feet) that do not merit FCS involvement. If a nearby building has an FCS installed, connect the small size building to the nearby FCS and use the FCS in lieu of the programmable time switch mentioned below.

Equip smaller buildings with a programmable thermostat that provides night temperature setback and disables cooling during unoccupied hours.

Buildings with central systems shall have the following special automatic controls:

A 7-day programmable time switch with a bypass switch to shut down the following:

- Noncritical exhaust system
- Heating water circulating pump and steam coil
- Supply fans
- Return-relief and noncritical exhaust fans
- Building air conditioning equipment, such as chilled water circulating pumps, heat pumps, or air conditioning condensers and compressors
- Domestic hot water circulating pumps
- Outside air dampers (close).

Provide the following to protect the building during extreme outside low temperatures:

- Thermostat located in a sensitive place in the building that will restart the following when the interior temperatures drop below 55°F

  - Supply fans, if the building does not have perimeter heating
  - Heating water circulating pump.

- Time-delay relay for fast warm-up to turn on the following if the building low-temperature thermostat has not reacted. (Provide a bypass switch around the timer.)
  - Supply fans
  - Heating water circulating pumps, or air conditioner and chilled water pump during summer
  - Bypass the hot water reset control from the normal heating schedule.

- Additional features to reinstate the building to normal operating status at the beginning of the work period per the following:
  - Startup of domestic heating water circulating pump
  - Startup of noncritical exhaust fans
  - Opening of dampers to the normal, mixed, and outside control position
  - Restart of the return-relief fans.

8.23 Vibration Isolation and Alarm

8.23.1 Design Conditions

Select rotating equipment to vibration levels measured in any plane on the bearing cap (in the installed and operating condition) in accordance with SNL/CA Standard Specification 200549, Mechanical and Piping Sound and Vibration Control. .

Show large supply fans, compressors, utility exhausters, and other rotating and reciprocating equipment mounted on vibration isolating bases incorporating springs, so 90 percent of the lowest disturbing frequency is isolated from the structure. Indicate in the equipment list the type of isolation that is to be supplied. Add special instructions for the equipment manufacturer to provide a coordinated isolation system.

Isolate mechanical equipment that has extremely high noise or vibration levels, including the distribution piping, on springs to minimize the transmission of vibration or noise into the building components and occupied spaces.

Connect an alarm signal to the FCS at the same location where special vibration switches are installed to shut down equipment.

8.23.2 Calculations Required

Provide written evidence of how isolation was selected for equipment installations that produce vibration or noise in usual ranges. Installation of equipment that produces extremely high levels of noise or vibration requires the following calculations:

- Static deflection
- Fundamental natural frequencies of machine mounting system.

8.23.3 General

Provide raised concrete pads isolated from the building structure with elastomer-bonded glass fiber material under all major items of equipment, pumps, etc. It is the responsibility of the mechanical designer to transmit this information to the structural designer so it can be shown on the structural drawings.

Make the final attachment of ductwork to fans with inorganic flexible connections. Use weatherproof connections when exposed to the weather. Flame-retardant flexible connections are generally recommended. Use noncombustible connections on piping that contains flammables. Use flexible connections to connect building piping to air compressors (see Chapter 8.15, Compressed-Air System Design).

Connect refrigeration piping to compressors with refrigerant pressure-rated flexible metallic sections, oriented parallel to the crank shaft.

Make final connections of fluid piping to pumps, towers, and other vibrating machinery with suitable flexible connections, such as "Resistoflex" bellows. Provide adequate anchoring of piping next to flexible connections.

Use spring-loaded pipe hangers when necessary to prevent vibration and sound transmission.

Add notes to the description in the equipment list to instruct the vendor of noise or vibration-producing equipment in excess of 5 hp. The vendor shall certify that the equipment and its supporting structures have been balanced statically and dynamically and that they are free from natural frequencies within 30 percent of its operating speeds.

Detail mounting frames where required (for example, roofs). Do not indicate overall dimensions. Relate the size to the equipment being supplied to obtain a coordinated system.

8.24 Sound Control

8.24.1 Design Conditions

Unless otherwise noted in the Design Criteria, establish design goals according to good engineering practice and the ASHRAE Guide and Data Book tables of design goals for sound control.

8.24.2 General

Minimize noise transmission throughout the structure. Establish that noise generated from outdoor equipment will not disturb neighbors or indoor occupants.

Select fans, or other equipment that radiate directly into an occupied area, that are quiet enough to meet ASHRAE noise criteria curves for the occupancy. Select diffusers and grilles with sufficiently low velocity to provide a noise level that meets the ASHRAE noise criteria curve for the occupancy.

Design or select sound attenuating devices as required to meet the ASHRAE noise criteria curve for the occupancy.

8.25 Insulation

8.25.1 Calculations Required

Specify insulation for ducts, piping, and heat-producing equipment to meet CA Energy Codes and ASHRAE 90.1.

Calculate the insulation thickness necessary to prevent condensation on piping where domestic cold water or chilled water lines with 65°F or cooler water runs through spaces where the pipe temperature could be below the dew-point. Comply with ASHRAE Standard 90.1.

8.25.2 Insulation Materials

Refer to SNL/CA Standard Specification Sections 200700, Mechanical Insulation,

8.25.3 Insulation – General

In no case specify or accept a combustible-type insulator or duct liner.

8.26 Water Treatment

8.26.1 Open Recirculating Systems

All cooling towers and fluid coolers shall have a water treatment system installed. Piping such that a sample line is taken from the tower water supply line, to a conductivity controller, and returned to the tower water return line. Provide chemical injection points downstream of the controller. Check valves shall be installed on either side of these chemical injection points on a vertical section of pipe so as to protect the controller and chemical feed tanks from reverse flow conditions. Minimize the use of pure chemical feed lines, when feasible to do so. Each system shall have:

- Sized make-up and bleed lines and valves
- Flow meters installed on both the makeup and bleed lines. These shall be pulsing-type flow meters, with an acceptable operating range. Where possible, the flow meters will be tied into the FCS.
- Conductivity controller(s) and associated flow switch(es) installed, but not calibrated.
- Provisions for the injection of biocide and scale/corrosion inhibitor chemicals downstream of controller by providing tie-ins for future installation of chemical feed lines (typically 3/8" or ½" lines).
- Sufficient footprint and wall space for tanks, flow meters, controller(s), and sample line.
- Sample line at controller.

Contact SNL/CA project lead for further details of open, recirculating water treatment systems.

8.26.2 Chilled and Hot Water Closed Loops

Make provisions for the periodic injection of corrosion-inhibiting and biocide chemicals on closed loop systems. Install chemical pot feeder with sufficient clearance to pour in 5-gallon drum of chemical. Standard chemical pot feeder shall be stainless steel with a 0.5-micron polypropylene bag filter, operating pressure up to 150 psig, operating temperature up to 200^{o}F, 40-gpm maximum flow and 3-psi pressure drop. Feeder shall be piped to the nearest floor drain. Consult SNL/CA Standard Drawings and the SNL/CA project lead for further details of closed loop water treatment systems.

8.27 Painting and Pipe Identification

8.27.1 General

Where practical, specify a factory finish for all mechanical equipment. Paint all other mechanical items except in the equipment rooms. See SNL/CA Standard Specification Section 099100, Painting.

After painting is complete, thoroughly identify all piping with appropriate Brady self-adhesive labels. Ensure that the mechanical contractor understands that he or she is responsible for the accuracy of labeling and the direction of flow.

8.27.2 Underground Utilities

Mark the location of all underground utilities with a continuous identifying tape buried in the pipe trench above the pipe. Refer to SNL/CA Standard Specification .312333 Trenching and Backfilling. In addition, mount utility marker posts with painted descriptive titles over underground utility lines in remote areas.

For utilities installed in remote locations, specify underground utility markers per SNL/CA Standard Drawing s, Utility Markers for Buried Pipe and Cable.

8.28 Test and Balance

The mechanical designer is responsible for determining the extent of Test and Balance that is necessary to prove that systems and equipment are operating as intended. Normally the Test and Balance service is provided by a Test and Balance agency hired by SNL/CA and working jointly with the construction contractor as specified in SNL/CA Standard Specification 230593, Testing, Adjusting and Balancing Air and Water. The designer is responsible for reviewing the final report to determine if the design intent will be achieved and for providing options on how to correct deficiencies.

8.29 System Installation, Startup, Testing/Balancing and Commissioning

Designers will ensure that all specifications and related construction documentation clearly stipulates the contractors, subcontractors and equipment suppliers are aware that their respective scopes of work include:

- Providing an Installation Checklist for all equipment indicating that all manufacturer installation requirements were met during construction

- Providing a Startup Checklist for all equipment indicating that all manufacturer startup criteria were met during equipment startup
- Providing any Testing/Balancing checklist as may be required during Startup operations
- Specify that all contractors be aware of the existence of the Project Commissioning Plan requirements so they will include Commissioning support as needed during commissioning testing phase(s).
- Specify that all contractors be aware of a 72 hour system function and system run qualification test and detailed performance documentation to support the testing is required and will be reviewed and approved.

9.0 Electrical Design

9.1 Purpose

The primary purpose of this standard is to achieve consistency in providing a minimum level of quality in electrical facilities engineering design at the SNL/CA.

It is not the intent of this standard to provide project-specific design criteria or serve as an instruction manual to untrained persons. It is also not the intent of this standard to repeat code requirements, except where necessary for completeness or clarity.

9.2 Design Requirements - General

These standards apply to all construction, including new construction and modifications to existing installations, on the SNL/CA site.

Due to the nature of certain installations, this standard does not cover the following:

- Power master substations
- Power transmission or overhead distribution lines

Refer to the project-specific design criteria for additional electrical design requirements. For products and construction methods, see SNL/CA standard construction specifications.

9.2.1 Standards, Codes and Regulations

Designs shall conform to this standard, and the requirements of the latest version of the following codes and standards:

- National Electrical Code, NFPA 70
- California Electrical Code, Title 24 Part 3
- California Energy Code, Title 24 Part 6
- Standard for Electrical Safety in the Workplace, NFPA 70E
- National Electrical Safety Code, IEEE C2

Nothing in this standard shall be construed to permit a design not conforming to applicable laws, ordinances, rules or regulations.

Resolve code conflicts by using the more-stringent applicable portion of conflicting codes, unless SNL/CA grants a written waiver.

9.2.2 Construction Documentation

Coordinate design with all disciplines, and include sufficient detail on construction drawings to allow for code review and contract bidding of the work. Design plans and/or drawings shall incorporate the following requirements:

- Use the list of standard symbols shown on SNL Standard Drawing E-001STD, and include the drawing in the construction package.
- Add other symbols not shown as needed.
- Keep abbreviations to a minimum.
- Use only standard technical abbreviations from the American National Standards Institute (ANSI) and IEEE on all drawings.

9.2.3 Future Expansion

Consideration shall be given to future expandability of the electrical design.

9.2.4 Exclusions

The following practices are excluded unless specifically approved by SNL/CA:

- Welding or cutting of structural steel for electrical systems
- Installing busway systems
- Using cable tray systems for power cables
- Installing underfloor duct systems

9.3 Access and Layout

- Electrical equipment must be accessible for periodic maintenance, repair, and replacement. This accessibility includes not only consideration of NEC 110.26 clearances, but paths of entry and egress to and from the clearance space; and the types of maintenance, repair, and replacement that might be needed over the useful life of the equipment.
- Anticipate and eliminate head-bumping and tripping hazards.
- Locate lighting fixtures so access for re-lamping and repair activities is maintained.
- Prepare elevations of crowded walls, particularly where the mechanical and structural equipment used for the maintenance of electrical equipment is located.
- Coordinate information on electrical drawings with structural drawings, so sleeves through walls and floors are accurately detailed and specified.
- Coordinate with mechanical and HVAC drawings, so each system properly fits into common spaces.

9.4 Medium- and High-Voltage Power Systems Design (> 600 Volts)

Refer to project specific Design Criteria for these requirements.

9.5 Low-Voltage Power Systems Design (<600 Volts)

9.5.1 General

This section describes general power requirements for low-voltage systems (those with system voltages less than 600 Volts).

9.5.2 One-Line Power Diagram

Develop or add to one-line diagram drawing (EP-series drawings) as noted below.

Starting at the top of the drawing with the building transformers, show all pertinent electrical equipment down to the panelboard level. This equipment includes switchboard/switchgear, panelboards, MCCs, generators, transfer switches, uninterruptible power supplies, and inverter systems.

For transformers, note kVA size, primary and secondary voltages, phasing (building service entrance only), and impedance. Show the distribution switchboard and switchgear in "expanded" form. On the drawing detail the main breaker, tie breaker, feeder breakers, spare breakers, CTs, PTs, and meter. Note switchboard rated amperage, voltage, and short-circuit capability. Include frame and trip size of all breakers in the gear.

Note service entrance, feeder wire and conduit sizes on drawing.

For larger buildings, additional one-line diagram drawings may be required. If the building uses motor control centers (MCCs), separate one-line diagrams may be required. When MCCs are necessary, provide them in "expanded" form. Drawings should be called "MCC One-Line Diagram" and be numbered sequentially with the main one-line diagram. Indicate starter and breaker sizes, bus tap sizes, wire, and conduit size ending with each motor or other load. If the building has a large standby power system, provide an "expanded" one-line diagram of this system also.

In general, use the following guidelines:

- If a building transformer is not associated directly with the building, start the one-line diagram with the largest distribution panelboard.
- If all details can be shown on one sheet, it is allowable to use "expanded" details on all necessary equipment.
- Place the highest-voltage lines at the top of the drawing with successively lower voltages placed downward.
- Use standard symbols listed on SNL Standard Drawing E-001STD and in ANSI standards.
- All "expanded" gear must be shown with a dashed outline. All singular items must be shown with solid outlines.
- Draw circuits in the most direct and logical sequence. Draw lines between symbols either vertically or horizontally with a minimum of line crossing.
- Note panelboards and major equipment locations (Column D4, NE Equipment Room, and so on). Try to group equipment on drawings by physical locations.
- To avoid clutter, do not put specialty symbols and construction notes on the one-line diagram. Grounding, controls, metering, and miscellaneous details should all be on separate drawings.

9.5.3 Metering

Electric metering is provided at all building service entrances and at disconnecting means downstream of the service entrances, as necessary to separately meter building and process loads.

- Show Current Transformer (CT), Potential Transformer (PT), and meter connections, also indicate CT and PT ratios on one-line diagrams.
- For indoor installation, locate meter, communication circuit connection points, and termination points on power plans.
- For outdoor installations, locate meter, communication circuit connections, and termination points on civil work (exterior utilities) plans.
- For metering specific to the building or facility, place details on EI-series drawings.
- When metering at switchboards or switchgear and panelboards, the meters must, where feasible, be supplied by the original equipment manufacturer and installed in the equipment. For other metering locations or equipment, the meter location and enclosure are as specified by SNL/CA.
- For low-voltage (120/208V and 277/480V) service-entrance installations, a 4-wire, wye-connected, 3-PT, 3-CT metering configuration is used. On medium-voltage (>600V) systems, a 3-wire, open delta-connected, 2-PT, 2-CT configuration is used. Reference the manufacturer's installation manual for detailed connection and other information pertinent to the meter.
- The installation shall include properly sized CTs, CT shorting blocks, PT/VT fuse blocks, and other standard hardware and wiring necessary to install the meter per the manufacturer's recommendations, and as constrained by this document. Revenue rated CT & PT shall be specified for where the revenue rated meter is specified.
- The voltage or PT primary connection is made on the line side of the service-entrance disconnect.
- Metering CTs should be sized for the full load current of the metered transformer, or the bus rating of the metered equipment, whichever is larger. Recommend multi ratio CT where applicable. Select CTs to reduce the rated primary current to 5 amps. The CTs may be located on either side of the service entrance disconnect.
- Metering requirements shall meet CEC Title 24 Part 6 Section 130.5.
- A RS-485 communications circuit or other dataway specified by the Electrical Systems Engineer is extended from the meters to the nearest telephone terminal cabinet. Where several meters are being installed in the same facility, meters are interconnected locally using an RS-485 data circuit, and a single communications home run is extended from the telephone terminal cabinet to the nearest meter. The communications circuit is terminated per the manufacturer's specifications.

9.5.4 Panelboards

Locate on power plan (EP-series drawings).

Panelboards must be designed as follows:

- Locate indoors where possible. Avoid outdoor or rooftop locations.
- Locate in hallways and dedicated electrical rooms or closets where possible; avoid user spaces.
- Flush-mount only in areas such as user hallways and office spaces. When flush-mounted, provide spare conduits, skirting, or other provisions to facilitate future modifications.

- Surface-mount in all other areas, including user labs, manufacturing spaces, equipment chases, and electrical or mechanical rooms.
- Panelboards located in areas accessible to users must be designed to have less than 1.2 cal/cm^2 incident energy exposure.
- Panelboards with greater than a 1.2 cal/cm^2 incident energy exposure must be located in electrical rooms or closets or mechanical or electrical spaces accessible only to qualified personnel, and have a rating of 22kAIC, minimum.
- Multiple section panels are not permitted. Where it is necessary to have more than 42 circuits in a lighting or appliance panelboard in the same location, use additional, separately circuited panelboards.
- Avoid subfeed or dual-feed lugs.
- Avoid individually mounted subfeed circuit breakers.
- Overcurrent protection of transformers is to be sized according to NEC 450.3 for any location. If a larger breaker is installed, the appropriate trip plug must be installed as well. It is not permitted for the trip settings to be dialed-down to meet the intent of this section.
- Panelboard naming conventions shall follow this scheme:

  VNA = where
  - V = Voltage, where P=277/480v and L=120/208v or 120/240v
  - N = Floor where panel is located
  - A = Sequence letter within this building and on this floor

  NOTE Some existing buildings do not follow this convention. New panelboards in these buildings are to follow existing building convention. Where a mixture exists, new installations are to comply with this naming convention.
- Oversize neutrals only when required per harmonic analysis. See subsection 1.12.7 for guidelines on harmonic analyses calculations.

Design panelboards with size and number of single-, double-, or three-pole circuit breakers required, and show on SNL schedule templates. When multi-pole breakers are scheduled with no further qualifications, provide same with a single operating handle. When multi-pole breakers are specifically called out as handle-tied single-pole breakers, provide same listed for such use. Single-handle multi-pole breakers must not be substituted for handle-tie requirements.

Design new panelboards so approximately 20% of the panel capacity is spare, both in connected load and in unused, installed circuit breakers or unpopulated spaces. Provide 10% spare breakers of the panel capacity in panelboard of the most common type/size breaker.

Power distribution system and the panel circuitry assignment shall meet CEC Title 24 Part 6 Section 130.5.

9.5.5 Low-Voltage Switchgear and Switchboards

Provide a construction specification for each new installation:

- Locate on power plan (EP-series drawings).
- Detail on one-line diagram, include all loads, circuit numbering and spaces.
- Provide elevation showing all circuit breaker locations and circuit numbering.

- Provide additional details, schedules, or other information on drawings as necessary for construction.

Low-voltage switchgear and switchboards shall comply with the following:

- Locate indoors where possible; avoid outdoor locations.
- Locate in dedicated electrical rooms accessible only to qualified personnel.
- Make front-accessible where possible, except service-entrance equipment.
- For service-entrance equipment, provide rear access when possible.
- Copper main bus; 100% capacity full length.
- Copper neutral bus, if required; 100% capacity full length.
- Copper ground bus; full length.
- Main and feeder circuit breakers arranged for compression connectors.
- All circuit breakers must be NEMA construction.
- All circuit breakers must have provisions for lockout/tagout (LOTO).
- All circuit breakers must include electronic interchangeable trip with adjustable LTPU, LTD, STPU, STD, and INST functions. When required, provide integral GFPU and GFD functions.
- When ground fault is required, provide two-level protection (main and feeders).
- Provide service-entrance label when required.
- Provide minimum 25 % spare capacity and 1 spare circuit breaker of each frame size (excluding main) used.
- Provide future bus extension and dedicated space for at least one future section.
- Provide integral Square D Power Logic metering located on the line side of the main (see subsection 1.5.3 for more information on metering).
- Provide integral surge protection device (SPD) to meet requirements of NFPA 780, when required.
- Where draw-out circuit breakers are specified, provide manufacturer's overhead lifting device suitable for all circuit breaker sizes and locations.
- Provide manufacturer's test kit for all circuit breaker types and functions used.
- All circuit breakers larger than 200 amps must be tested.
- Overcurrent protection of transformers is to be sized according to NEC 450.3 for any location. If a larger breaker is installed, the appropriate trip plug must be installed. It is not permitted for the trip settings to be dialed-down to meet the intent of this article.
- Switchboard naming must follow a similar scheme as for panelboards.
- Oversize neutrals must be used only when required per harmonic analysis. See subsection 1.12.7 for guidelines on harmonic analyses calculations.
- Power distribution system and the switchboard circuitry assignment shall meet CEC Title 24 Part 6 Section 130.5.

9.5.6 Low-Voltage Dry Type Transformers

Provide construction specification or specify on drawings and equipment lists.

- Locate on power plan (EP-series drawings).
- Provide additional elevation or mounting details as required for construction.

Low-voltage dry transformers shall comply with the following:

- Locate indoors where possible; avoid outdoor locations.
- Energy-efficient; meeting NEMA TP-1 and DOE minimum efficiency standards.
- Specify transformer to include +2/-4 at 2.5 percent taps.
- Transformers located in areas accessible to users must be designed to produce less than 10,000A available short-circuit current.
- Transformers allowing more than 10,000A available short-circuit current must be located in electrical rooms, closets, or mechanical or electrical spaces accessible only to qualified personnel.
- When a panelboard fed from a dry transformer cannot be installed in sufficient proximity to its associated transformer to allow the secondary conductors to be protected per section 240.21(C)(2) of the National Electrical Code ("10-foot rule"), an enclosed circuit breaker installed adjacent to the transformer must be used. Fused safety switches must not be used for this purpose.

9.5.7 Motors

Locate on power plan (EP-series drawings)

Motors that are controlled by across-the-line motor starters and are 25 HP or larger must include power-factor-correction capacitors at the motor starter to achieve 95% power factor. Motors controlled by VFDs are excluded from the power-factor-correction requirement.

Nominal voltages for motors not a part of programmatic equipment shall be as follows, unless unique and specific design considerations require otherwise and are stated on the drawings:

- Fractional-horsepower, single-phase – 120V
- 1 to 5 horsepower, three-phase – 208V preferred, 460V permitted
- 5 to 150 horsepower, three-phase – 460V
- Above 150 horsepower – 4,000Vpreferred, 460V permitted. Equipment with motors of this size and larger must be specified by a construction Special Spec.

9.5.8 Motor Control Centers

Provide a construction specification for each new installation.

- Locate on power plan (EP-series drawings).
- Detail on one-line diagram, include all loads, circuit numbering, and spaces.
- Provide elevation showing all starter locations and circuit numbering.
- Provide additional details, schedules, or other information on drawings as needed for construction.

Motor control centers (MCCs) shall meet the following:

- Locate MCCs indoors where possible; avoid outdoor locations.
- Locate MCCs in dedicated electrical rooms accessible only to qualified personnel.

- Make front-accessible where possible.
- Use copper main bus; 100% capacity full length, minimum 600A.
- Use copper neutral bus, if required; 100% capacity full length.
- Use copper ground bus; full length.
- Wire MCCs for NEMA Class I, Type B.
- Starters must be combination type with motor circuit protector, contactor, and LOTO provisions.
- Circuit protectors, contactors, overload blocks, and all accessories must be of NEMA construction.
- Starters must include overload reset button, red and green LED pilot lights, red for run mode and green for stop. Pilot-light assemblies must be supplied with removable lenses allowing lamps to be replaced from controller exterior.
- Provide HOA in cover; minimum 2-N/O and 2-N/C auxiliary contacts and individual control power transformer (CPT) if above 150V to ground.
- A control power transformer, if required, must be sized for 100 VA extra capacity and include 2 primary and 1 secondary fuses for 120V control.
- Do not mount panelboards or associated transformers in MCCs.
- Provide future bus extension and dedicated space for at least one future section.
- Provide minimum 25% spare amperage capacity and 10% spare buckets for each size provided.
- Motor control center naming must follow a scheme similar to that for panelboards, except the sequence number must include the letters **_MCC**.

9.5.9 Individual Motor Starters

- Locate on power plan (EP-series drawings)
- Individual motor starters (non-VFD) must be as follows:
  - Locate indoors where possible; avoid outdoor locations.
  - Starters must be combination type with motor circuit protector, contactor, and LOTO provisions.
  - Circuit protectors, contactors, overload blocks, and all accessories must be of NEMA construction.
  - Starters must include overload reset button, red and green LED pilot lights, red for run mode and green for stop.
  - Provide HOA in cover; minimum 2-N/O and 2-N/C auxiliary contacts and individual CPT if above 150V to ground.
  - A control power transformer, if required, must be sized for 100 VA extra capacity and include 2 primary fuses and 1 secondary fuse for 120V control.

The use of "intelligent" starters or other control devices that operate by a remote or on-board microprocessor must be plainly identified, along with provision for communications dataways necessary to support the proper programming, operation, and monitoring of the device by the FCS, process control equipment, or both.

Variable frequency controllers must be as follows:

- Locate indoors where possible; avoid outdoor locations.
- Propose VFDs to the Mechanical Engineer.

- A manual by-pass is not usually required on a VFD. A by-pass should only be specified after discussing the requirements with the Mechanical Engineer.
- Do not install VFDs closer than 5 feet to an FID cabinet for heat protection.
- The use of "intelligent" VFDs that operate by a remote or on-board microprocessor must be plainly identified, along with provision for communications dataways needed to support the proper programming, operation, and monitoring of the device by the FCS, process control equipment, or both. This addresses control and monitor features separate from the simpler 4-20ma or pneumatic circuit that commands VFD motor speed. See SNL Standard Specification 200515, *Variable-Frequency Controllers*, for VFD requirements.

9.5.10 Feeder and Branch Wiring

- Home runs for receptacle, power, and lighting may be indicated with an arrowhead, panel/terminal cabinet number, and circuit/terminal block number. This method may be used for branch circuits and terminal loads; all feeders and conduit 2 inches or larger must have designed runs designated on the drawings.
- Identify the conduit size and the numbers and types of conductors it contains.
- For typical circuits, this information may be listed by general note. For example, "All conductors are 12 AWG THHN/THWN in 3/4-inch conduit unless otherwise noted."
- Refer to Standard Specifications 260519 and 260533 for minimum conductor and conduit sizes and types, respectively.
- Individual circuits between light fixtures and to light switches may be indicated by showing switch letter and circuit number at each fixture.
- Show exterior conduits running to or from a building on electrical and civil work (exterior utilities) site plans.
- Circuitry must run overhead; do not run in slab, and avoid under slab when possible.
- Group 120V branch circuitry into multiple ABC sets, with a shared ground and individual neutrals where possible. Identify each neutral with a color stripe that is the same as the phase color it supports. Multiple circuit sets must originate from adjacent ABC circuit breakers. If all loads are single-phase, such as through three-phase whips supplying modular furniture, the adjacent breakers must also be three 1ϕ circuits; however, if neutrals must be shared (on existing installations only), a single multipole circuit breaker must remove power from all phases returning through that neutral. Calculations must show whether a shared neutral must be upsized.
- Group circuit home runs where feasible, derated as required, and show on drawings. Do not leave the derating calculation up to the construction contractor.
- Provide a dedicated neutral conductor all circuits. Reduced-size neutrals are prohibited without prior and specific SNL/CA approval.
- Provide equipment-grounding conductor sized per the National Electrical Code® (NEC®) with all power and control circuits over 50 volts.

9.5.11 Other Design Requirements

- Specify that all floor-mounted electrical equipment be installed on a 3½" housekeeping pad.
- Indicate all fire-barrier penetrations on electrical plan drawings.

- Specify the method of sealing openings on electrical plan drawings, and coordinate all sealants used with the Architectural Designer.
- In general, equipment specified must meet the energy-efficiency requirements of 10 CFR 436, Subpart A and CEC Title 24 standards.
- Provide a telecommunications drop for metering at service entrance electrical equipment rooms that are 100 square feet or larger. Provide an additional telecommunications drop adjacent to a Facilities Control System (FCS) cabinet, preferably in an equipment room.
- Provide a separate and local disconnecting means for mechanical equipment requiring line electrical power. The disconnecting means must be separate from the equipment, but may be mounted on it, and must be operable without any disassembly or opening of the equipment access covers. It must have provisions for lockout-tagout (LOTO), and must be rated for the service and location, including any motors in the equipment. In addition to those disconnecting means required by NFPA 70, SNL's requirement includes, but is not limited to, fan-coil units, variable-air-volume boxes, lighting fixtures, damper and valve actuators, small exhaust fans, and the like. The branch-circuit circuit breaker servicing the assembly must not be used to satisfy this requirement. Coordinate the requirements for this disconnect with the assigned SNL Electrical Systems Engineer.

9.6 Receptacle Design

Locate on power plan (EP-series drawings)

Design the receptacle system per the following minimum requirements:

- Flush-mount outlets in areas such as lobbies, conference rooms, user hallways and office spaces.
- Surface-mount outlets in areas including user labs, manufacturing spaces, equipment chases, and electrical or mechanical rooms.
- Exterior outlets are to be equipped with a cover that retains its weather-resistant quality with cords plugged in.
- For new construction, do not provide outlets within 6 feet of the vertical axis of emergency showers and eyewash stations. For modifications, remove, relocate, or both, outlets that fall within 6 feet of new emergency showers and eyewash stations.

Comply with 2013 California Energy Code Title 24 Part 6, regulation on controlled and uncontrolled receptacle circuits.

In buildings where electric personnel vehicles are assigned, provide one dedicated 120-volt 20-amp GFCI-protected simplex receptacle per cart station on the exterior of the building at cart parking locations. Provide a weather cover, so the receptacle meets NEMA weatherproofing standards with or without the cart-charger cord plugged in. Carts draw 8 to 13 amps at the maximum charge rate.

Where the building is expected to have wall-mounted television sets connected to the SNL Video Network, provide a duplex receptacle high on the wall (60"AFF nominal) at the television's location. This circuit need not be dedicated. The duplex receptacle is required for the television and for its fiber-optic modem.

Where the building is expected to have wall-mounted Tone Alert Radios, provide a simplex receptacle high on the wall (72" to 96"AFF nominal) at the device location. The radio need not be on a dedicated circuit. If the building is to have a central public address (PA) system, consider locating a single Tone Alert Radio at the PA chassis and connecting its output through the PA system as an economy measure.

Note that the Tone Alert Radios themselves must be mounted nominally at 72" AFF, so their controls are within reach.

Where the building is expected to have special and Twist-Lock® single- and multiphase receptacles, select receptacles from NEMA configuration families L5, L6, L7, L21, and L22. Wiring service to the j-box on which these receptacles are mounted must include a neutral and ground, regardless of whether the receptacles require these conductors. Multiphase receptacles rated for more than 50 amps per phase should be of the pin-and-sleeve type, with a sleeve length sufficient to conceal the pins during make-and- break operation, and provided with a 15° back box and hub for surface mounting.

9.7 Lighting Systems Design

This section describes the philosophy, required performance and features, and prohibited features and equipment for interior and exterior lighting systems design.

9.7.1 Interior Lighting

Locate lighting fixtures on reflected ceiling plans (EL-series drawings).

This section strives to provide adequate, comfortable, and reliable indoor illumination levels for tasks without over-lighting the workspace and wasting energy, and in a manner that can be serviced regularly without extraordinary maintenance procedures or equipment.

The preferred indoor general lighting fixture is the straight, 3500°K 48-inch F32T8 lamp as described in SNL Standard Specification 265100, *Interior Lighting and Controls*. The 24-inch F17T8 lamp is to be used in 2-by-2 fixtures. However, other new technology cost effective energy efficient luminaries shall be proposed to the SNL/CA Project Lead. When ceiling height, equipment clearances, or both, dictate certain high-output and MHID fixtures may be authorized indoors, but only in the following situations:

- In fixtures where the lamp is shielded from direct view
- In high bays where the lamp is some distance from the observer and with specific approval of the SNL Electrical Engineer

Maintenance of fixtures, such as cleaning and replacing lamps and ballasts, is one of the most important design considerations and can override architectural considerations when life cycle cost is considered. Do not locate fixtures where they cannot be safely reached by ladders or lamp snatcher poles. Do not permit other disciplines to occupy space below the fixture-mounting planes. Ensure that fixtures are placed in areas that do not conflict with air diffuser patterns, sprinkler heads, and other utilities above the ceilings. Coordinate with Mechanical if heat-removal fixtures are anticipated. Do not specify exotic or expensive lamps and components when standard equipment can be used without sacrificing adequate performance. If special access or handling equipment is needed to service luminaires, specify this information as part of the project design. Proactively determine the programmatic use of the space, and do not locate fixtures where later installation of programmatic equipment might block fixture access. If this cannot be avoided or fully anticipated during the design phase, provide alternative access, such as catwalks.

Present or describe a fixture mounting detail for every fixture, using standard drawing details wherever possible.

Where night lights are required and inverter-powered emergency fixtures are part of the general illumination layout, connect these lights to the inverter's normally on output. Be sure that the sum of the

power requirements for the normally on and off circuits do not exceed the inverter's rating. All inverter-powered fixtures are to be identified with a label visible from the floor.

> **NOTE** High-intensity discharge fixtures may not be placed on an inverter circuit unless specifically required by the design criteria and equipped with a quartz restrike unit. Most emergency lights should be LED.

When two discrete illumination levels are wanted from a 3- or 4-lamp fluorescent fixture, the use of Advance VEL-4P32-2LS ballast and one switch are preferred in lieu of two ballasts and two switched conductors. When a continuously variable illumination range is wanted, use in-line dimmers and ballasts where the circuit to be dimmed can be held to 1,000 watts or fewer. Where this is not practicable, such as in theater-style conference rooms, use 0- to 10-volt ballasts and master dimming controllers. Require the application of a maintenance warning label, if the controller's 10-volt power is provided from other than the main lighting circuits being dimmed.

Perform lighting design and control per the 2013 California Energy Code Title 24 Part 6. Prepare lighting design photometric layout and Title 24 calculation.

- Provide these average illumination levels in the following spaces, measured at the work surface with all fixtures at full brightness, 15% variance permissible:
  - 20 foot-candles (fc) in halls at floor level, with 1 fc for night emergency egress
  - 30 fc at floor level in occupied warehouses, dropping to 10 fc when unoccupied, except that any requirement for vertical illumination in the design criteria takes precedence over this general requirement
  - 30 fc in conference rooms, lobbies, and informal meeting centers
  - 35 fc in small offices with indirect lighting and furniture-mounted task lighting, but measured with the task lighting off
  - 45 fc in general offices; maintain 3:1 ratio between general and task lighting
  - 60 fc in light laboratories

Color rendition index (CRI) for general interior lighting must be 75% or better.

The following features and equipment are prohibited:

- Incandescent lamps and fixtures, except for HID restrike units, low-voltage MR fixtures used for display highlighting, or where an incandescent spectrum is specifically required by the design criteria
- F96T12, F96T12HO, F96T12VHO, F40T12, F34T12, and F54T5HO lamps and fixtures
- T12U6 or U8, T8U3, and circular fluorescent lamps and fixtures
- Compact fluorescent lamps over 26 watts, unless the fixture provides adequate cooling
- Downlights with CFs mounted horizontally high in the can close to an unvented reflector
- Downlights or other fixtures with ballasts not accessible from the lamp opening, when used in a hard ceiling
- Fixtures where the lamps are very close together and luminaire efficiency is thereby reduced, unless specifically required by the design criteria
- Fixtures with specular egg-crate grids (use low-iridescent diffuse silver models)
- Preheat magnetic ballasts
- Rapid-start ballasts, unless specifically required by the design criteria

- Any rapid-start ballast that fails to turn off heater power after lamp ignition
- High-pressure sodium (HPS) or other "nonwhite" lighting inside a regularly occupied building, unless specifically required by the design criteria
- Self-powered battery life safety fixtures, except where an inverter is not available
- High-intensity discharge fixtures on an inverter circuit

9.7.2 Exterior Lighting

Locate fixtures not mounted on buildings on civil work (exterior utilities) site plans (WJ-series drawings)

Design must consist of energy efficient cost effective "shoebox" full-cutoff light fixtures on round, steel, tapered poles that meet the standards of the American Association of State Highway and Transportation Officials. Pole height and lamp wattage are determined by the size of the area to be illuminated and must consist of equipment specified in the Exterior Lighting Equipment Schedule. If solar-powered light fixtures are used, contact the Facilities Electrical Systems Engineer to specify the fixtures.

Exterior building lighting must be switched by an integral, individual photocell with an override switch accessible to qualified maintenance personnel. The preferred fixture for exterior doors is the 50- to 70-watt MHID or more energy efficient cost effective wall-pack with lamp shield, polycarbonate lens, and a body color that coordinates with the building's color scheme. For walkway illumination, a bollard 50- to 70-watt MHID or more energy efficient cost effective fixture with lamp shield and polycarbonate lens can be used (maximum height of 5 feet, otherwise design must be any other energy efficient cost effective shoebox fixture with round, tapered, steel pole as indicated above). When the fixture must be mounted low and close to personnel so the MHID fixture's brightness is objectionable, and when MHID illumination levels are not required architecturally or by Security, a similar compact fluorescent fixture may be used.

Perform lighting design and control per the 2013 California Energy Code Title 24 Part 6. Prepare lighting design photometric layout and Title 24 calculation.

Coordinate exterior lighting and pole-mounted lighting with the Facilities Electrical Systems Engineer. The Security department might have additional requirements for minimum illumination levels and for maximum illumination variance between fixtures as needed for intruder assessments. Provide these average illumination levels in the areas shown, measured at grade with all fixtures at full brightness, zero sky contribution, 15% variance permissible:

- 5 fc at building entrances, with 1 fc for night emergency egress
- 2 fc at gates and perimeter fences where security assessment is an issue; maintain 4:1 ratio between maxima and minima
- 1 fc in parking lots; maintain 4:1 ratio between maxima and minima
- ¼ fc along illuminated roadways, with 2 fc at major intersections

9.8 Control System Design

Show on control (EI- or MI-series drawings) or power plans (EP-series drawings) as detailed in this section.

9.8.1 General

Control systems include, but are not limited to, the following:

- Laser interlocks
- Facilities Control System (FCS)
- Motor control other than HVAC controlled by FCS

For interior lighting controls, see subsection 1.7.1, "Interior Lighting."

9.8.2 HVAC and Facilities Control Systems

Electrical and Mechanical Designers are jointly responsible for HVAC controls:

- Prepare elementary diagrams per subsection 9.8.3.
- Refer to subchapter 8.22 for FCS design standards.
- Coordinate electrical equipment noted in the mechanical plans.

9.8.3 Elementary Control Diagrams and Symbols

Use a ladder layout when preparing elementary control diagrams. Simple power wiring and control circuits (for example, those that use only one simple control switch or a normal light switch) are exempt from these requirements.

Use the symbols shown on electrical standard drawings E-001STD for elementary diagrams. If components are required that are not included on this drawing, use symbols included in ANSI Y32.2, *Graphic Symbols for Electrical and Electronics Diagrams*.

9.8.4 Sequence of Operations

On simple control systems, the sequence of operations shown on the mechanical drawings suffices, if the elementary control diagram is properly cross-referenced.

Always present a sequence of operations on the electrical drawings for other than simple control systems and for control systems involving only electrical apparatus.

Begin the sequence with the system turned off, carry it through each operational step, and explain the operation of each component throughout its normal operating conditions.

9.8.5 Control Wiring Conduit Layout—All Systems

If possible, show control plans on power plan drawings. If not workable, create a separate set of control plans.

9.8.6 Laser Interlock Systems

Contact the Laser Safety Officer in the ES&H Customer Support Teams (3127), for the latest laser-safety requirements.

9.9 Building Grounding System Design

At a minimum, provide the following:

- Grounding plans
- Grounding one-line diagram
- Grounding details
- Grounding plans and grounding details to be placed on ES-series drawings

The drawings must show interconnection of the following:

- All metal systems of the building, such as the following:
  - Interior and exterior water system
  - Metal ductwork
  - Building steel
  - Lightning protection system
  - Made electrodes
  - Building foundation rebar
- Where in the electrical system bonding is required
- Where the grounding electrode system connects into the rest of the grounding system
- Any other special requirements for the building grounding system (that is, static or signal grounds)
- The size of all required grounding conductors (grounding electrode conductor, equipment grounding conductors, and main bounding jumpers)

The design must address the NEC as a minimum requirement, and must address other factors when designing the system, such as 60 Hz grounds, harmonics, shielding, signal and data grounds, and lengths of grounding conductors to ground.

Given that the purpose of the insulated equipment grounding conductor is to conduct fault currents back to their point of origin; therefore, all separately derived systems (excluding a building's service entrance equipment) must have an equipment grounding conductor run from the source of the separately derived system through the distribution and control equipment to the loads. The equipment grounding conductor must be bonded to the grounded circuit conductor (neutral) at the source of the separately derived system. Refer to Standard Grounding Drawings.

Where a lightning protection system is required, provide a ground counterpoise. Where a lightning protection system is not required, provide grounding per the NEC and SNL/CA Standard Specification 260526 Grounding and Bonding for Electrical Systems.

9.10 Identification and Labeling

9.10.1 General

To ensure a minimum standard of quality, identify devices, fittings, fixtures, and equipment on equipment list drawings with their electrical sizes, ratings, manufacturers, and catalog numbers. This level of identification is not necessary for items such as panelboards, where complete specifications are written.

Identify motor starters on the motor control schedule. Identify all equipment by using standard symbols and equipment schedules. In addition to the items already mentioned, the schedule should include information to help the contractor obtain the equipment and materials intended by the design.

Specify nameplates on all control items used on the job. Specify each nameplate either on the motor schedule or on the equipment list. Each nameplate identifies the system and the function of that device to the system.

9.10.2 Electrical Equipment Labeling Designations

The labeling for all panelboards, switchboards, motor control centers, and switchgear must have a consistent nomenclature and circuit designation to provide a basis for systematic identification of components in the field. This requirement also applies to control stations, transfer switches, and equipment of communications and auxiliary systems. See the labeling instructions SNL/CA Standard Specifications 260553, Identification for Electrical Systems.

9.10.3 Electrical Equipment Labels

Labels are required on each unit of equipment, including the central or master unit of each system. This requirement includes power, lighting, telecommunications, signal, and alarm systems, unless units are specified with their own self-explanatory identification.

Refer to Standard Symbols List drawings E-0001STD, Electrical Standard Symbol List/General Notes, and E-0011STD, Sample Electrical Equipment Schedule.

9.10.4 Wiring Device Identification and Labeling

On the plan view, identify each device, its corresponding source, and the circuit number accompanying it. For example, in "P3A-1" the P3A represents the panel name, 1 represents the circuit number. Labeling of wiring devices must comply with SNL Standard Specification 260553, Identification for Electrical Systems.

9.10.5 Conductor Identification and Labeling

All conductors must be identified with the source the conductor is fed from and circuit number information. Conductor insulation of power circuits and secondary-phase conductors shall be color coded as noted on standard drawing E-001STD and SNL Standard Specification 260519 Low Voltage Electrical Power Conductors and Cables. For multiple power or lighting circuits in the same enclosure: Identify each conductor with source, voltage, circuit number, and phase. Refer to SNL Standard Specification 260553, Identification for Electrical Systems for conductor labeling.

9.11 Standby and Emergency Power Systems

Any new standby or emergency generator systems are to have diesel engines as the prime mover and load banks rated for 100% of the generator output. Once the decision has been made to install a standby or emergency generator system, contact SNL Environmental Management for assistance in obtaining a permit from the Bay Area Air Quality District. Obtaining a permit may be an extended process.

Automatic transfer switches for standby and emergency power systems must be four-pole switches. For emergency power systems, the automatic transfer switch must have bypass and isolation switches. For standby power systems, evaluate and recommend the need for isolation and bypass switches.

- Locate building generators on power plans (EP-series drawings) or on the electrical site plan (ES- or WP-series drawings).
- Prepare detail drawings as needed for construction.
- Locate transfer switches, inverters, and feeders on power plan.
- Show transfer switches and identify equipment fed from emergency power system on the one-line diagram.

9.11.1 Standby Power

If standby power is determined to be required for an SNL/CA facility, conduct a preliminary standby load study for review and determination of the appropriate source of standby power for the proposed standby power loads by the Electrical System Engineer.

9.11.2 Emergency Power

If emergency power is determined to be required, conduct a preliminary emergency load study for presentation to the assigned Facilities Electrical System Engineer who determines the appropriate source of emergency power for the proposed facility.

9.11.3 Emergency Lighting Power

Provide battery-powered emergency and egress lights for all facilities requiring emergency and egress lighting.

9.11.4 General

Present all electrical calculations using the guidelines in this section. Provide two 8½-inch by 11-inch, three-hole-bound reports that contain all electrical calculations, time-coordination curves, and protective device settings with final drawing submittal. Provide one-line diagrams and all electronic files with all calculations. During construction support services, update calculations based on contractor submittal before approving any submittal. Provide a complete set of calculations to the contractor (via RFI process) upon request. Ensure that the manufacturer's catalog data on the affected protective devices show they have adequate fault current interrupting capacity for the available short circuit current. These calculations should be made available in electronic format to SNL immediately upon request.

9.11.5 Voltage-Drop Calculations

Prepare and submit a complete set of voltage-drop calculations. When both normal and standby primary feeders serve a facility, provide calculations for both feeders. The preferred calculation method is the SKM Systems Analysis Dapper software program.

The maximum allowable steady state voltage drop must not exceed 5% total for building wiring.

The maximum allowable transient voltage drop must not exceed 15% at the utilization equipment. If a problem is identified, notify the assigned Facilities System Engineer for resolution.

Design the standard voltage profile for regulated power distribution systems to comply with ANSI/IEEE Standard 141-1993 (Red Book) or the latest edition.

Calculate voltage drops for the longest-branch circuit to include the drop in feeders, subfeeders, and transformers back to the first bus with automatic regulation (usually the primary master unit substation). Do not use a building transformer to correct secondary voltage drops. Set transformer voltage taps to nominal voltage values under no-load conditions.

Unless loading can actually be predicted, assume the full load for all branch circuits as that limited by the maximum load on the conductors by these standards, applicable codes, or both. The power factor for future loading is considered to be the same as when designed.

9.11.6 Short-Circuit and Arc-Flash Calculations

Prepare and submit a complete set of short-circuit, breaker coordination, and arc-flash calculations when modifying power distribution system. At a minimum, provide the above when adding a panelboard and/or a 10HP motor or larger. When both normal and standby primary feeders serve a facility, provide calculations for both. The fault-duty calculation method shall be SKM Systems Analysis Dapper and Captor software programs. Obtain specific building SKM files as the starting point and update with new project information (when available).

Calculations must consider both bolted three-phase and single-phase-to-ground fault current on secondary systems. State the base MVA or KVA available at the fault. Arc-flash calculations must include the calorie levels, PPE requirements, hazard categories, and boundary dimensions for all equipment that may be serviced or used for troubleshooting while energized. The calculations must include the data necessary to completely execute the information and warning label to be applied to the equipment covers as shown on SNL Standard Drawing E-001STD.

Prepare protective device coordination graphs that demonstrate that the protective devices are properly coordinated for interrupting faults. Prepare these graphs for all new or modified primary and secondary systems. Also, verify existing equipment settings and provide calculations from new equipment through existing equipment to the service entrance.

The design shall include the use of S&C, SMU unit (e.g. SMU-20 for a 200 amp continuous rating), 14.4kV, Type to be determined by the site/project condition (e.g. E-type), standard-speed fuses in 15 kV S&C padmount or stand-up switchgear, unless approved otherwise by the Facilities Systems Engineer.

Additionally, present the manufacturer's catalog data on the affected protective devices to show they have adequate fault-current interrupting capacity for the available short-circuit current.

9.11.7 Wire-Pulling Calculations

When new ducts are required for primary power system (>600V), submit a set of calculations showing the maximum tension placed on the cables during pulling and the maximum allowable tension the cables can withstand. Calculate also, from a pressure standpoint, the force exerted in each elbow or bend during pulling and the radius of each bend. The minimum radius for electrical duct banks is 3 feet. Calculations must be performed in both directions with resultants indicating either direction of pull is allowable. Indicate the resultant radii on the plans, plus the pulling instructions that are required for the method and direction.

9.11.8 Lighting Calculations

Calculate the horizontal illumination levels for each room using the zonal-cavity method described in the *Illuminating Engineering Society (IES) Lighting Handbook*. Similar-sized rooms may be reported under a single spreadsheet calculation when the illumination level does not vary more than 5% to 10% across the group of rooms. When intense point sources, such as MHID lights, are used for indoor lighting, perform an additional spot check for hot spots and uniformity using the point-by-point method.

Constants, such as lumen output per lamp, fixture efficiency, maintenance factor, or coefficient of utilization, must be shown with the source of the constants identified, such as a product cut sheet. In most cases, the maintenance factors should be chosen on the basis of a medium-intensity maintenance program, full-rated voltage applied, no temperature derating, and a 5% tolerance for lamp burnout. Coordinate expected wall, ceiling, and floor reflectance with architectural finishes, and explain significant excursions from the 80/50/20% standard.

Calculate the vertical illumination level for those rooms and spaces where adequate illumination on walls, display cases and boards, or shelves is important to the mission of the room.

Calculate the visual comfort probability in the manner described in the *IES Lighting Handbook* for all rooms in excess of 40 feet in length and width, or when directed by the electrical design criteria. Where other than "white light" (low CRI, or significantly off 3,500°K) is used, calculate the human eye response to the spectrum provided, and provide the equivalent effective illumination level had "white light" been used.

Specify the operating point of adjustable automatic switching controllers, such as at what ambient conditions the controllers are to function both on and off. Include delay times and sensitivity settings for occupancy sensors, ambient light levels for daylight-harvesting controls, and timer settings.

Use the point-to-point method to develop isolux curves for design of parking, ground, flood, or perimeter fence lighting systems to design the required horizontal footcandle levels and uniformities at ground level. Submit the isolux curves as part of the design package.

Options for calculations include commercial software programs explained in the *IES Lighting Handbook*. Identify the program used by trade name and version number.

In addition to the above, lighting levels, controls and shall comply with the California Energy Code, Title 24, Part 6.

9.11.9 Exterior Lighting Calculations

Use isolux curves to design ground or fence lighting systems to obtain the required minimum footcandle level, horizontal, at ground level. Submit the isolux curves used for cross-checking.

9.11.10 Harmonic Analyses Calculations

Prepare and submit harmonic study calculations when a significant amount of harmonic (nonlinear) load is added to the distribution or building power system. A harmonic study is also required when the new load exceeds the recommended voltage or current distortion levels as allowed by IEEE Standard 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*.

The design must include a system that limits the voltage and current distortion at the point of common coupling per the limits recommended by IEEE 519-1992. SNL/CA provides the existing power system information.

The results of the harmonic study dictate when additional harmonic correction measures are required.

9.12 Access and Layout

- Electrical equipment must be accessible for periodic maintenance, repair, and replacement. This accessibility includes consideration of NEC 110.26 clearances; paths of entry and egress to and from the clearance space; and the types of maintenance, repair, and replacement that might be needed over the useful life of the equipment.
- Anticipate and eliminate head-bumping and tripping hazards.
- Locate lighting fixtures so access for relamping and repair activities is maintained.
- Prepare elevations of crowded walls, particularly where the mechanical and structural equipment used for the maintenance of electrical equipment is located.
- Coordinate information on electrical drawings with structural drawings, so sleeves through walls and floors are accurately detailed and specified.
- Coordinate with mechanical and HVAC drawings, so each system properly fits into common spaces.

9.13 Sandia-Furnished Material

Unless specifically indicated in the electrical design criteria, SNL/CA furnishes the following equipment:

- Emergency light system inverter
- HVAC controls equipment and components as listed in 8.22.1.11

9.14 Acceptance and Commissioning Testing

Acceptance testing is required on all new electrical equipment prior to energizing it and placing it into service. Testing must be performed by a third-party testing firm, meeting all qualifications stated in the latest edition of the ANSI/International Electrical Testing Association (NETA) document, *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*. Also, all

acceptance testing must be performed in accordance with the latest edition of *ANSI/NETA Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems*.

Electrical system commissioning testing is required to ensure the installed electrical systems, including but not limited to, lighting control/photometric performance, electrical control and switching operation system, phasing test, etc., perform according to design.

All tests shall be observed by an authorized SNL/CA representative, documented in a report, and submitted to SNL/CA for approval.

10.0 Telecommunications Design

Design the telecommunications systems per the separate *Telecommunications Systems Design Manual*, or other guidance as provided by the Project Design Criteria or as directed by the SNL/CA Project Lead.

Note that the above referenced Sandia Telecommunications Systems Design Manual applies only to the building's telecommunications equipment and its performance. References in that Manual are made to numerous building systems such as HVAC and power, and provide the performance requirements for those systems as they affect telecommunications. However, such building systems remain under the responsibility of the SNL/CA Facilities Management, and adequate design for access, compatibility with other building systems, and similar requirements listed in this Design Standards Manual must be provided. In the event that different requirements for such building equipment are identified between the two Manuals, the SNL/CA Design Standards Manual shall take precedence.

Ownership of this Chapter of the CA Design Manual rests in Sandia department 8949 Communication and Networking Systems. Contact Marcia Jacobs, for telecommunications engineering support, or for network engineering support contact Rich Gay. Contact the CCHD/One Service Desk for all other questions.

11.0 Security Design

NOTE Unless specifically stated, the names of the organizations, teams, projects, program, and job titles described in this chapter should be assumed to be internal entities at SNL/CA).

11.1 Introduction

This chapter of the *Design Standards Manual* (DSM) provides guidance to ensure that appropriate physical security considerations are included in the design of new facilities. It describes security construction requirements that must be addressed during the design and construction phases of any project. This chapter is co owned by the SNL/CA Security Department and SNL/CA Facilities Management.

Interface with Safeguards and Security (S&S)

According to Chapter 2.0, General Design Standards and Procedures, security system modifications, no matter how small, must be coordinated with through the Safeguards and Security Request (SSR) process. Additionally, as described in ISS100.3.1, *Report Personnel Security Information; Security Incidents; and Waste, Fraud, and Abuse,* unauthorized modifications to security components, infrastructure, or systems, including unscheduled power outages, are DOE-reportable security incidents.

As part of the SSR process, the SNL/CA Security Department reviews and then approves or denies changes to add, modify, or remove security features to any area, building, room, or structure.. Approved projects receive a formal SSR work authorization response package that authorizes security resources to be involved in a project. As part of the package, an SNL/CA Security Department Point of Contact (POC) may be assigned as the central point of contact for all project-related coordination. The SNL/CA Security Department works with the SNL/CA Project Lead. All communications and requests should go through the SNL/CA Security Department POC, when one is assigned. For the purpose of brevity, the remainder of this Chapter will refer to the SNL/CA Security Department POC as SNL/CA Security Department

For an authorized project, SNL/CA Facilities Management, contractors, and employees must do the following:

- Communicate with and through the assigned SNL/CA Security Department for additional design and coordination information.
- Consult with the SNL/CA Security Department for intrusion alarm (IA) sensor layout inside a Closed Area (soon to revert to Vault-type Room (VTR)).
- Request, through the SNL/CA Security Department, the current approved equipment list from the SNL/CA Security Department for each project. Do not use lists from past projects, since the approved equipment list is updated regularly. The SNL/CA Security Department selects and specifies the approved equipment for each project.
- Participate in design reviews and coordinate changes as follows:
  - Review the designs with the assigned SNL/CA Security Department upon the completion of the Title II design.
  - Formally document each design change recommended by the SNL/CA Security Department as accepted or rejected.
  - Formally document the final acceptance of the design as directed by the SNL/CA Project Lead and the SNL/CA Security Department: Provide a complete set of as-built drawings to

the SNL/CA Security Department (1); upon completion of the design for new work, removals, or the relocation of any component; and (2) as construction Change Orders modify the original design.

11.2 Security Area Boundaries

11.2.1 Design Philosophy

Security Areas (SAs) are used to protect S&S interests and government property. The SAs described in this subsection are Property Protection Areas (PPAs) and Limited Areas (LAs). Designs for other SAs, such as Protected Areas (PAs) and Material Access Areas (MAAs) are not common and require close coordination with the SNL/CA Security Department; therefore, PAs and MAAs are not covered in this manual.

This section identifies specific SA design standards to ensure the areas meet the requirements of several DOE and NNSA policies. As part of the overall security system, additions and modifications to an SA must be coordinated with the SNL/CA Security Department through the SSR process prior to design. SNL/CA Security Department determines whether the security system can support the proposal.

11.2.2 Security Area Stand-off

When designing new facilities, CA Project and Engineering Systems Engineers and external architectural and engineering (A/E) Engineers and Designers must consider the stand-off distance imposed by DOE Order (O) 470.4B Change 1, dated 2-15-2013, *Safeguards and Security Program, Attachment 4, Section 3.b.(3).(d)*. If this stand-off distance cannot be met for either limited space or per customer request, contact SNL/CA Security Department for further guidance.

11.2.3 PPA Boundary

11.2.3.1 General Requirements

Property Protection Area (PPAs) are created for the following security interests or activities:

- Nuclear materials requiring safeguards controls or special accounting procedures (Category IV special nuclear materials or SNM)
- Property of significant monetary value (contents greater than $5M)
- Site-identified essential facilities
- C4 (command and control, computing, communications) facilities
- Facilities containing property inherently dangerous to others
- Facilities storing arms, ammunition, or explosives
- Facilities housing hazardous material meeting certain conditions (Contact Physical Security for further information.)

NOTE If such a facility is located within a fenced compound, preference is given to extending the PPA boundary to the compound perimeter, except where contraindicated because of operational requirements or undue expense.

PPAs are established to protect government-owned property against damage, destruction, and theft. Barriers and associated access controls must be installed to control public access.

Barrier design must control, impede, or deny access to an SA. The barrier may include fences and building perimeters. Contact the Physical Security Program Lead for facility characterization and PPA/GAA barrier requirements.

Temporary fencing for PPA boundaries must be installed when the fencing is affected by construction activities; however, temporary fencing must comply with the protection goals and operational requirements established for the affected PPA. Physical Security must conduct a design review for all temporary fences.

11.2.3.2 Signage

All signs must be in compliance with the Sign Standard for Interior/Exterior/Civil/Regulatory/Physical Security Signs.

The following signs must be posted as described:

- "No Trespassing" signs at PPAs boundaries along the following:
  - Building, turnstile, and gate entrances
  - External building walls without an entrance, at least one per wall
  - Fence or boundary, at least every 200 feet
- "Prohibited Articles" signs at PPA boundary gates, turnstiles, and main entrances to buildings.
- "Video Surveillance" signs (if installed) at PPA boundary gates, turnstiles, and main entrances to buildings.
- "Atomic Weapons and SNM Rewards Act" signs at gates, turnstiles, and main entrances to buildings.

11.2.4 LA Boundary

11.2.4.1 General Requirements

Permanent LAs at SNL/CA are established for the following security interests or activities:

- Use, processing, or storage of Category III Sandia Nuclear Material (SNM)
- Protection of classified matter

Permanent physical barriers must be installed to identify the boundary of an LA. Physical barriers must be installed to deter unauthorized access. Barriers must be designed to direct the flow of personnel and vehicular traffic through designated entry control points. Additionally, designs must ensure that overhead utilities do not pass into the LA without physical protection, and elevators that penetrate the LA must be provided with an Access Control System (ACS).

11.2.4.2 Fenced LA Boundaries

Fences must be installed in accordance with the standard specifications and drawings described in Chapter 3.0, "Civil Design." Fences must be installed as follows:

- For standard security fence fabric, use a 2-inch-square or smaller mesh of No. 11 American wire gauge (AWG) galvanized steel or heavier steel wire.
  - Use wire ties to fasten fence fabric to poles. The ties must be of equal tensile strength to that of the fence fabric. The use of aluminum ties or fence fabric **is prohibited**.
  - Seek approval to use alternative fencing materials. Alternative materials may be approved for use in lieu of the standard security fencing; however, the penetration resistance must be the same or greater than the resistance of the standard security fence. Contact the SNL/CA Security Department and request approval to use alternative fencing. Alternative fencing materials must be approved by SNL/CA Security Department prior to use.
- Ensure overall fence height, excluding outriggers and barbed wire or barbed tape coil topping, is at least 7 feet. See Chapter 3.0, "Civil Design," for details.
- Install the fence no less than 20 feet from the building or security interest being protected. If this distance is not possible, contact the SNL/CA Security Department. The SNL/CA Security Department determines supplementary protective measures that must be applied, such as extending the fence height.
- Establish a 10-foot clear zone along each side of the security fence to facilitate intrusion detection and assessment.
- Landscaping, parking, storage or utilities cannot be installed within 10 feet of either side of the security area fence. This requirement ensures the clear zones are clear of vegetation, equipment, and other objects that could impede observation or facilitate bridging. If this is not possible, contact the SNL/CA Security Department and request a consultation with the Physical Security representative.
- Install fence posts, bracing, and other structural members on the high-security side of the fence.
- Install the fence so the bottom of the fence is no greater than 2 inches from firm ground. If the soil is unstable or subject to erosion, extend the fence below the surface.
- Ensure vertical gaps do not exceed 6 inches in width at any point, from the ground to the top of the fence, where the fencing meets gates, turnstiles, or other structures constituting the LA boundary.
- Secure the gate hardware by brazing, peening, welding, or applying an epoxy that prevents removal of hardware accessible from outside the security area.
- Stabilize surfaces in areas where loose sand, shifting soils, or surface waters could cause erosion.
  - Suspend additional fencing from the lower rail of the main fence for elevation changes and depressions that can be stabilized, but cannot be leveled.
  - Provide concrete curbs, sills, or a similar type of anchoring device extending below ground level if surface stabilization is impossible or impractical.
  - Block areas subject to water flow under security fencing with wire or metal bars that not only provide for the passage of floodwater, but also a penetration delay equal to that of the security fence.

The following signs must be posted on the LA fencing:

- "No Trespassing" signs at all entrances and every 200 feet along the fence, if the LA boundary is not within a posted PPA boundary.
- "Prohibited/Controlled Article" signs at main entrances.
- "Video Surveillance" signs (if applicable) at main entrances.
- "Atomic Weapons and SNM Rewards Act" signs at main entrances.

Proposals for using temporary fencing must be coordinated with the SNL/CA Security Department to ensure the fencing complies with the SAs protection goals and operational requirements. Proposals for temporary fencing must be reviewed and authorized by SNL/CA Security Department. SNL/CA Security Department must also conduct a design review for all temporary fencing projects.

11.2.4.3 Turnstiles

SNL/CA Facilities Management takes responsibility for gates and turnstiles and their designs and locations. Turnstiles must be designed and integrated into the security area boundary in a manner that prevents its use as a climbing aid to breach the perimeter. For a turnstile, specify the following:

- Two, full-height, single security turnstiles configured side by side to allow both entry and exit from an area.
- Turnstile equipment from the standard drawing.
- A security bypass gate at all turnstile locations.

All proposed turnstile locations must be coordinated with the SNL/CA Security Department.

11.2.4.4 Buildings as the LA Boundary

Most standard building materials, as specified in Chapter 3.0, "Civil Design," and Chapter 6.0, "Architectural Design," meet security requirements when selected and designed for penetration resistance to and evidence of unauthorized entry into the LA. All LAs must meet the following additional design requirements:

- **Walls**
  - Extend from the true floor to the structural ceiling.
  - Use insert-type panels that cannot be removed from outside the LA without showing visual evidence of tampering.
- **Doors**
  - For doors constructed with transparent glazing material, offer penetration resistance to and evidence of unauthorized entry into the area.
  - For doors that allow potential visual access to classified, install a sight baffle.
  - For storefront-type doors, ensure the door is capable of retrofit with the electric strike as required for the ACS.
  - For doors with external hinges outside of the LA, ensure the door hinges have nonremovable hinges/pins.

- For outward-swinging doors, if it is possible to manipulate the door latch, install a latch guard. Ensure the latch cannot be removed from the outside.
- Install an astragal or mullion along the full length of the door where doors are used in pairs. Ensure the astragals or mullions are reinforced and not removable from outside the LA.
- Ensure emergency and evacuation exits do not include hardware that allows access from outside the LA.
- Do not use magnetic locks because of conflicts between fire code and security requirements.

- **Windows**
  - Ensure windows are fixed (nonoperable) and panes cannot be removed from the outside in LA boundaries.
  - For windows that allow potential visual access to classified, install a sight baffle over the window.

- **Openings**
  - Ensure all openings greater than 96 square inches and greater than 6 inches at its smallest dimension (or circular openings greater than an 11-inch diameter) that penetrate the LA boundary (for example, ductwork and utility chases), are protected. Use physical protection with 18-gauge (or greater) expanded metal or ½-inch rigid steel bars, welded vertically and horizontally 6 inch on center, to provide the necessary barrier delay.
    - If barriers cannot be installed, protect the opening with IA sensors.
    - If the opening is movable, protect the opening with IA sensors.

- **Signage**

  Post the following signs on buildings that are part of an LA boundary:

  - "No Trespassing" signs at all entrances and at least one sign on each side of the building without an entrance, if the LA boundary is not within a posted PPA boundary.
  - "Prohibited and Controlled Article" signs at main entrances.
  - "Video Surveillance" signs (if applicable) at main entrances.
  - "Atomic Weapons and SNM Rewards Act" signs at main entrances, if the LA boundary is not within a posted PPA boundary.

11.2.5 Security Area Entry Point Lighting

Lighting at Security Area entry points must meet the following requirements:

- It must enable assessment of unauthorized activities, persons, or both, at pedestrian and vehicular entrances and allow examination of DOE security badges and inspections of personnel, hand-carried items, packages, and vehicles.
- It must be positioned so PF personnel are not spotlighted, blinded, or silhouetted by lights. The lighting placement and design should enhance, not minimize, PF night-vision capabilities.

11.3 Vaults and Closed Areas

11.3.1 Design Philosophy

Vaults and Closed Areas are used to store S&S interests and located within or comprise an LA. This section describes vault and Closed Area design standards, so they meet DOE requirements. Except where otherwise stated, the term "Closed Area" includes vaults. Since DOE requirements often change and affect existing installations, these standards were developed to provide the most cost-effective implementation for the life cycle of a vault or Closed Area. Any proposed designs that do not conform to these design standards must be approved by the SNL/CA Security Department through the SSR process. Because of an effort to reduce the numbers of vaults and Closed Areas at SNL/CA, requests for new vaults and Closed Areas must have sufficient approved justification.

11.3.2 Vault Construction

Vault construction standards must comply with Federal Standard 832, *Construction Methods and Materials for Vaults*. Vaults must be constructed to meet construction requirements in NNSA Administrative Policy (NAP) 70.2, *Physical Protection,* Chapter IX, "Secure Storage." A vault is a penetration-resistant, windowless enclosure that has doors, walls, floor, and roof/ceiling designed and constructed to significantly delay penetration from forced entry and equipped with IDS devices on openings allowing access. The material thickness must be determined by the requirement for forcible entry-delay times for the S&S interests stored within, but must not be less than the delay time provided by a minimum 8-inch-thick reinforced concrete poured in place, with a minimum 28-day compressive reinforced strength of 2,500 pounds per square inch.

If 8-inch-thick reinforced concrete is not used, vault designs and calculations must be constructed to meet an equivalent penetration delay. SNL/CA Security Department must approve the alternate design and associated delay calculations. Rooms that do not meet the equivalency requirement must be installed per Closed Area construction requirements.

A vault door and frame must meet the highest level of penetration resistance of the General Services Administration (GSA). The lock on the door must be a minimum of a GSA-approved lock. Vault doors protecting classified matter must have a lock that meets *Federal Specification* FF-L-2740A, "Locks, Combination." Kaba Mas X-08™, X-09™, or X-10™ combination locks are the only locks that meet these requirements at SNL/CA. Locks must be installed by the SNL-designated locksmith. The Lockmasters, Inc. LKM7000, "Exit Device," is the only DOE-approved device that can be installed with the X-09 or X-10. If the LKM7000 is not installed, establish administrative controls for the activation of the "Life Safety Pin" on the XO-series locks that meet requirements in NFPA® 101, *Life Safety Code.*

Vault doors protecting unclassified weapons or ammunition may use either an approved combination lock, internal locking device (ILD), or padlock. Combination locks protecting weapons and ammunition must meet the requirement of *Underwriters Laboratories (UL) Standard,* UL 768, "Standard for Combination Locks," Group 1 or *Federal Specification,* FF-L-2937, "Combination Lock, Mechanical." If using an ILD or padlock, contact Physical Security for further guidance and specifications.

Install a balance magnetic switch (BMS) on all doors and openings that allow access to or egress from vaults that alarm at the Central Alarm Station (CAS).

Vaults equipped with automated access control must have the override lock rekeyed to a Level III lock by the SNL/CA-designated locksmith.

Vaults are constructed with only one entry door unless additional doors are needed to meet requirements in NFPA 101, *Life Safety Code.* However, the locking hardware on the egress or service doors must still meet the lock and penetration delay requirements.

11.3.3 Closed Area Construction

Closed Areas must be constructed to meet the construction requirements in NAP 70.2, *Physical Protection,* Chapter IX, "Secure Storage." A Closed Area is an area that meets the requirements of NAP 70.2, *Physical Protection*, for safeguarding classified matter, a security interest, or both, that, because of size, nature, or operational necessity, cannot be adequately protected by the normal safeguards or stored during nonworking hours in approved containers. A BMS and volumetric coverage must be used on each door or engineered opening to allow detection of attempted or actual unauthorized access. Historically, DOE requirements for Closed Areas were established for storage of classified matter and not necessarily for human occupancy; therefore, optimum construction is for small windowless enclosures that are of substantial construction and without penetrations greater than 96 square inches. Closed Areas differ from vaults in that intrusion-detection coverage is required to detect penetrations through engineered openings (those openings designed and constructed to allow access to storage locations [for example, a door]).

Closed Area construction must offer substantial resistance to unauthorized entry into the area. The Closed Area design must consider the types and configuration of classified matter or assets that may be stored within the Closed Area throughout its use. Tradeoffs may be made between the physical features of the Closed Areas and the sensor coverage; however, the initial sensor coverage design may not address all future Closed Area configurations nor easily address future changes in requirements.

The perimeter walls, floors, and ceiling must be permanently constructed and attached to one another. All construction must provide visual evidence of unauthorized penetration. The following standards are required for all new construction, modifications, and repairs of existing areas:

11.3.3.1 Walls

Except as allowed, the walls must be windowless and constructed of brick, concrete, or corrugated metal, optimizing the usable wall space within the Closed Area. Storage of and the potential future storage of classified matter on or near the wall requires either an adequate physical barrier or intrusion detection between the asset and the wall consistent with that required to remove or compromise the asset.

Walls must be constructed to extend from the true floor to true ceiling. For more information, see also the design information on "Ceilings and Floors."

Wall design must minimize the number of penetrations. Incorporate supplemental barriers if any penetrations are greater than 96 square inches (or 6 inches on one side). For more information, see "Other Openings/Penetrations."

11.3.3.2 Ceilings and Floors

When a false ceiling is required below the true ceiling or roof pan, the false ceiling must be constructed of material offering resistance to and detection of unauthorized entry. Wire mesh or other non-opaque material offering similar resistance to, and evidence of, unauthorized entry into the area may be used if visual access to classified matter is not a factor.

Acoustic lay-in (suspended) ceilings may be installed below the true ceiling. Because of the resulting interstitial space, the Technical Security Systems Representative must evaluate the protected asset and

penetrations to determine if sensor coverage is required, and may require sensors within the interstitial space.

Alternatively, a suspended ceiling with ceiling tile clips may be installed. If ceiling tile clips are used, a minimum of four clips must be installed per ceiling tile. The clips must be installed from the interior of the area, and each clip must be mounted to preclude surreptitious entry. Penetrations greater than 96 square inches through the clipped ceiling must be protected by securing to the ceiling grid or to a supplemental barrier.

When wall barriers do not extend to the true ceiling and a false ceiling is created, the false ceiling must be reinforced with wire mesh or 18-gauge expanded metal to serve as the true ceiling. Or, the ceiling tiles must be secured using another appropriate method (for example, clips or caulking).

Ceiling tiles must not span Closed Area boundary walls. Design of suspended ceilings must ensure ceiling tiles at walls are large enough for tile clip installation. For modifications to existing Closed Areas with tiles that do not have a support grid, four tile clips must be installed, if the tile is large enough. Additional clips must be required in the following circumstances:

- Three sides have supports; use two clips on one side.
- Two sides have supports; use two clips per side, and install two clips as close to the wall as possible.
- A tile is not large enough for four clips; install as many clips as possible. Apply adhesive caulk between the tile and the support on the sides without clips.

Access, or raised, flooring may be installed above the true floor to allow for computer or other cabling. Because of the resulting interstitial space, the Technical Security Systems Representative must evaluate the protected asset and the protection of penetrations to determine if sensor coverage is required within the interstitial space. When the interstitial space is greater than 6 inches between the false floor or ceiling, the Closed Area program must use the following criteria to determine if alarming is required:

- Open storage (covered/shielded)
- Classified discussions (intermittent, not scheduled)
- No access to adjacent uncontrolled space

If any or all of the above apply, no alarms are required in the interstitial space. This includes Technical Security Counter Measure (TSCM) considerations. The protected interests are considered when not installing sensors between the true floor or ceiling and the false floor or ceiling.

11.3.3.3 Doors

Specify a solid-core wood door (minimum 1.75-inch thick) or a metal door of substantial construction. The doors for a Closed Area must be installed as follows:

- Install only one entry door at the entry control point.
- Install an X-08 or X-09 combination lock with the Lockmasters Inc. LKM7000 "Life Safety Exit Device" on the entry door. The LKM7000 is the only DOE-approved device that can be installed with the X-09. If the LKM7000 is not installed, establish administrative controls for the activation of the "Life Safety Pin" on the XO-series locks that meet requirements in NFPA 101, *Life Safety Code*. The LKM should be configured so that the doors swing outward only.
- Aligned and installed without gaps or openings on any side.

- For paired doors, install overlap molding (astragal) for the length of the doors where the doors meet.
- Secure windows, service panels, door louvers or baffle plates, or similar openings with 18-gauge expanded metal fastened securely on the inside of the Closed Area.

A Closed Area must be designed with the minimum number of service and emergency egress portals. During the renovation of an existing Closed Area, remove any unnecessary doors. For new construction of a Closed Area with an asset that is or might be visually classified, windows are not allowed. For renovations, replace any doors having windows with solid doors. At a minimum, install a sight baffle (for example, blinds or shades) over the windows.

Minimize the use of other egress or service doors. Egress or service doors, without the X-08 or X-09 combination lock, may have an electric strike for automated entry, but must have substantial locking hardware accessible only from inside the Closed Area. Install egress doors only as required by NFPA 101, *Life Safety Code*. Install service doors and roll-up doors only when operationally required and approved by Physical Security.

Closed Area doors must be equipped with eyebolts, which must be used for the application of security seals, as required. The eyebolts must be as follows:

- 1-inch long with a minimum 0.4375-inch opening and 2.25-inch rod
- Compliant with the fire ratings of the door or frame
- Mounted on doors approximately 1.5 inch from the edge
  - For single doors, one welded onto the door and one on the door frame, such that either bolt cannot be rotated. Mount one eyebolt vertically (with a 90 degree angle between the two eyebolts) and no more than 2.5-inch center-to-center from the other eyebolt.
  - For double doors, mount one eyebolt horizontally and the other eyebolt vertically, with 54 inches (±3 inches) above the finished floor.
- Welded on the door frame and located in the center of the molding horizontal to the floor. Ensure the eyebolts cannot be rotated.
  - For single doors, weld an eyebolt on the door and another on the door frame.
  - For double doors, weld one eyebolt to each door.

11.3.3.4 Sealing Closed Area Doors

- Closed Areas are designed with a minimum number of service and emergency egress portals. They have egress doors as required by life safety codes. Service doors and roll-up doors exist within Closed Areas only when operationally required and approved by Technical Security Systems.
- Fire Protection: An exit door may be sealed as long as the required common path of travel of 100 feet is not exceeded, and it is permitted to be blocked by the International Building Code (IBC). The sealed door must have a "no exit" sign posted above the door to notify the occupants that the door is not operational.
- In areas used or occupied as a high-hazard operation (Groups H-1, H-2, and H-3), the common path of egress travel must not exceed 25-feet.
- In areas used or occupied as a high-hazard operation (Groups H-4 and H-5), a single exit is permitted with a maximum occupant load of 10 persons.

- In areas used or occupied as an office, storage or utility, and miscellaneous operation (Groups B, S, and U), a single exit is permitted with a maximum occupant load of 29 persons.

11.3.3.5 Securing Metal Doors

For inward-swinging doors:

- Tack-weld a 5-inch bead (length of the hinge) at each hinge on the inside of the door.
- Tack-weld a 5-inch bead on the opening side, one above and one below the latch on the inside of the door.

For outward-swinging doors:

- Tack-weld a 5-inch bead (length of the hinge) at each hinge on the outside of the door.
- Tack-weld a 5-inch bead on the non-hinged side of the door, one above and one below the latch on the outside of the door.

NOTE Paint the welds to match the color of the door.

11.3.3.6 Securing Wood Doors

Use a metal cross bar with 3/8 minimum bolts anchored to wall. The cross bar must be 1” x 3/16” minimum thickness and installed on the inside of door.

11.3.3.7 Door Locks and Door Hardware

Closed Area doors must have locks that meet *Federal Specification,* FF-L-2740A , "Locks, Combination." Only the Kaba Mas X-08 or X-09 combination locks meet this requirement. Locks must be installed by the SNL/CA-designated locksmith.

Heavy-duty builder's hardware must be used and securely fastened to preclude surreptitious removal and to ensure visual evidence of tampering. Nonremovable pin (NRP) hinges must be installed on Closed Area hardware accessible from outside the area. The NRP hinges must be pinned, brazed, or spot-welded to preclude removal.

Deadbolts with an interior handle-operated release or other locking mechanisms must be of heavy-duty builder's hardware and meet requirements in NFPA 101, *Life Safety Code.*

Only approved panic hardware (for example, the LKM7000) must be linked to the spin-dial lock. Panic hardware or lever latch sets on emergency doors must be operable only from the inside and must not have exterior hardware.

When automated access control with an electric strike is installed, the door locking mechanism must include an appropriate Security Level III lock installed by the SNL/CA-designated locksmith.

11.3.3.8 Roll-Up Doors

The use of roll-up doors must be limited to Closed Areas that require the movement of large items in and out of the Closed Area. Closed Areas must not be constructed at existing locations with roll-up doors,

unless the door is replaced with a hard wall or is required for the Closed Area mission. Roll-up doors must be as follows:

- A minimum of 26-gauge galvanized steel, interlocked together to form a continuous curtain with interior and exterior polypropylene wear strip for the full height of the door.
- Equipped with a bulb astragal and bottom weather strip on the bottom bar of the door to ensure closure and fit along the floor. The bottom bar of the door may be made of reinforced aluminum.
- Equipped with two 10-gauge (minimum) slide locks, one on each side, that lock from the interior of the Closed Area.
- Equipped only with an interior roll-up door electric operator, including controls. See Chapter 6, "Architectural Design Standards"; Chapter 6.3, "Architectural Design Requirements"; Chapter 6.3.4, "Interiors"; and Chapter 6.3.4.3, "Doors," for more information.

11.3.3.9 Windows

As much as possible, windows must not be used in Closed Area designs. Windows that open must not be used in new construction designs. Windows must meet the following requirements:

- For renovations in which a window opens, the window must have either 0.5-inch rigid steel bars, welded vertically and horizontally 6 inches on center, or minimum 18-gauge expanded metal installed, such that the barrier cannot be removed from outside the area of protection.
- Window frames must be securely anchored in the walls, or installed in fixed (nonoperable) frames, such that the panes cannot be removed from outside the area under protection.
- When the Closed Area stores visually classified assets, install visual baffles, such as blinds or shades on windows.

11.3.3.10 Other Openings and Penetrations

Openings greater than 96 square inches and greater than 6 inches at the smallest dimension, (greater than an 11-inch diameter) must be protected. Use a minimum 18-gauge expanded metal or 0.5-inch rigid steel bars, welded vertically and horizontally 6 inches on center, to provide the necessary barrier delay. If barriers cannot be installed, intrusion detection must be provided to protect the opening.

Circular openings greater than 11-inches in diameter must be protected by minimum 18-gauge expanded metal or 0.5-inch rigid steel bars, welded vertically and horizontally 6 inches on center, to provide the necessary barrier delay. If barriers cannot be installed, intrusion detection must be provided to protect the opening.

Air supply and return ducts must be installed such that an adversary cannot crawl into the Closed Area undetected. (See also Chapter 8, "Mechanical Design Standards," Chapter 8.3, "Access and Layout," Chapter 8.3.2, "Security Requirements.") Openings and penetrations must meet the following requirements:

- Equip duct penetrations with barriers installed at the Closed Area boundary for penetrations larger than 96 square inches in area and more than 6 inches in the smallest dimension or greater than an 11-inch diameter. Ensure penetrations (for example, lights, diffusers, and air return grids) are secured to the ceiling brackets or tiles or have a supplemental barrier installed.
- Penetrations less than 96 square inches or less than an 11-inch diameter are acceptable without additional protection.

If standard physical options are not possible to protect a penetration, contact the Technical Security Systems Representative to obtain approval for the installation of intrusion-detection sensors.

11.4 Construction Standard Specifications

When making any changes to the security system, review the following specifications and drawings for general guidance and an overall understanding of how the system is constructed:

- SNL/CA Standard Specifications
  - 280515, *Intrusion Alarm System*
- SNL/CA Security Department standard drawings

Contractors and employees must request access to SNL/CA Facilities Management and demonstrate need-to-know (NTK) for this material. To request access to restricted S&S specifications and drawings, contact the SNL/CA Security Department. Once access is granted to these items, contractors and employees must implement the appropriate levels of protection in accordance with corporate process IM100.2, *Manage and Protect Information*, and corporate procedure IM100.2.5, *Identify and Protect Unclassified Information.*

11.5 SCCS Design

The security system at SNL/CA consists of an Access Control Systems (ACS) and an Intrusion Detection Systems (IDS). Physical Security determines whether security requirements mandate the need for buildings, mobile offices (MOs), trailers, and temporary structures to be connected to the ACS and IDS.

The S&S ACS/IDS at SNL/CA is an Alarm Communications and Display (AC&D) system that receives input from thousands of field sensors, reports to the Central Alarm Station (CAS) operators, and facilitates the rapid assessment and response of alarms at various security areas.

11.6 SNL/CA Security Department GEDII System Design

Systems Engineers in the SNL/CA Facilities Management department, along with external A/E Engineers and Designers generally must limit a design to the following:

- Equipment and cabling as specified by SNL/CA Security Department -approved equipment list, and approved standards
- Selecting, specifying, and laying out cabinets and boxes per SNL/CA Security Department requirements
- Selecting, sizing, and laying out raceways (conduits) per SNL/CA Security Department standard cable callouts
- Selecting and specifying cables (media) that are to be pulled in
- Identifying and providing dedicated 120VAC circuits as needed to power equipment

In addition, system engineers and A/E engineers must ensure that any optical-fiber media specified on any project is terminated, tested, and certified in accordance with SNL/CA Standard Specification, 270520, *Fiber Optic Communication Systems*.

Furthermore, A/E Engineers must consult and gain approval for the system configuration with the SNL/CA Security Department at each step in a design process. The SNL/CA Security Department provide technical oversight and ensure that only approved equipment and materials are selected and properly installed. Equipment substitutions and "or equal to" specifications **are not allowed**.

11.6.1 Autonomous Control Unit Cabinet

An Autonomous Control Unit (ACU) cabinet can manage up to 10 alarm points (for example, motion sensors and emergency exit doors with BMS sensors) that may be home-run to and terminated in the cabinet. An ACU can also handle a total of 16 devices (for example, readers and Remote Input Module or RIM cabinets), but no more than 8 RIMs. If an additional ACU is needed to handle the sensors and devices in a Closed Area, mount the ACU inside the Closed Area.

Specify the following for the ACU cabinet:

- 30- x 24- x 6-inch NEMA 1 cabinet (Hoffman catalog number A30N24ALP or an appropriate outdoor cabinet from the current SNL/CA Security Department equipment list)
- 4-inch square junction box with a NEMA 5-20R 20A (120VAC, double duplex receptacle) in the lower-left corner of the ACU cabinet
- 2-inch conduit between the ACU cabinet and its associated interface cabinet
- Two 2-inch conduits between the ACU and its associated 6- x 6- x 48-inch NEMA 1 gutter
- 1-inch conduit between the ACU and its associated door strike power supply cabinet, as necessary

Install the ACU cabinet as follows:

- Review the SNL/CA Security Department standards for the orientation of these cabinets.
- Install the cabinet in the area selected by the SNL/CA Security Department.
- Identify a dedicated NEMA 5-20A (120VAC) circuit for the ACU.
- Install a tamper switch to be connected to the security system.
- Place all exterior doors on one port and all interior doors on the second port in the ACU, where possible. This configuration assists in troubleshooting and maintenance.
- Install the reader loops in a serial string. Do not use a "star" configurations or loop back to the ACU.
- Lock the cabinet with a Level IV (administrative) lock. The SNL/CA Security Department provides or approves the lock.

11.6.2 Remote Input Module Cabinet

Install the Remote Input Module (RIM) cabinet as follows:

- Install a RIM cabinet for buildings or Closed Areas that require more than 10 sensors. Each RIM can handle an additional 16 alarm points. Although each ACU can handle a total of 16 devices (for example, readers and RIMs), add no more than 8 RIMs to an ACU.
- Select the installation location for RIMs to keep their cable lengths from the sensors to a minimum; this requirement most likely entails mounting the RIM remotely from the ACU. Locations near emergency exit doors are preferred. Mount the RIMs and ACUs in an easily

accessible location that meets National Electrical Code (NEC®) requirements and allow for system maintenance.

- In a Closed Area, install a RIM for every 16 sensors after the first 10.

11.6.2.1 ADA Doors

Technical Security Systems interfaces the security system with Americans with Disabilities Act (ADA) doors, if possible. The SNL/CA Security Department does not install, design, maintain, repair, or troubleshoot any ADA equipment, other than the interface with the security system. A Systems Engineer or A/E Designer coordinates ADA door designs with the SNL/CA Security Department and SNL/CA Project Lead as early as possible to ensure compatibility and suitability. The security system controls access and ADA functions for a single door.

Install the ADA door installed as follows:

- Review the "Automatic Door Operator Button Placement" requirement in the SNL/CA Facilities Management Architectural Accessibility Requirements for a typical layout.
- Design, specify, and install ADA automatic door opener interface, including any needed power supply or dedicate electrical circuit, per the ADA requirements and guidance from the SNL/CA Security Department.
- For an ADA door design that calls for a set of doors separated by a vestibule, install two sets of ADA pushbuttons in the vestibule area. In this configuration, the security system only interfaces with the exterior door. The interior door is operated by the pushbuttons. If space is too limited to meet this requirement, do not attempt to change the configuration to install the doors. Instead, use a single ADA door without a vestibule.

11.6.3 Interface Cabinet

For the interface cabinet, specify the following:

- 14- x 12- x 12-inch NEMA 1 cabinet (Hoffman catalog number A14N124 [for indoor application only])
- 2-inch conduit between the interface cabinet and the ACU
- ¾-inch conduit between the interface cabinet and the Security Fiber Termination (SFT) cabinet in the Intermediate Distribution Room (IDR). This conduit requires a 6-fiber, interior Systimax TeraSPEED (5200 006A WRYL) riser cable and an alarm cable from an ACU to a tamper switch in the SFT cabinet. Only one conduit between the SFT and the interface cabinet needs the alarm cable. For a building with more than 1 ACU, use the closest ACU.

Install the interface cabinet as follows:

- Mount the interface cabinet adjacent to the ACU cabinet.
- Mount the interface cabinet outside of the Closed Area on a wall adjacent to the ACU.
- Install a tamper switch. Connect the switch to the system at an alarm point (which is available in the ACU) with a “C” cable in the 2-inch conduit connected to the ACU. The 2-inch conduit also requires a minimum of three CAT 6 cables and one power cable between the ACU and the interface cabinet.

- Lock the interface cabinet with an administrative (Level IV) lock. The SNL/CA Security Department provides or approves the lock.

11.6.4 SFT Cabinet

For the IDR wall-mounted SFT cabinet, specify the appropriate-sized cabinet with a hasp and staple for padlocking:

- 20- x 20- x 8-inch NEMA 12 cabinet (Hoffman A202008LP). This cabinet accommodates up to 24 fiber terminations and requires one LIU and one vertical trough.
- 30- x 20- x 8-inch NEMA 12 cabinet (Hoffman A302008LP). This cabinet accommodates up to 48 fiber terminations and requires two LIUs and two vertical troughs.
- 36- x 24- x 8-inch NEMA 12 cabinet (Hoffman A362408LP). This cabinet accommodates up to 72 fiber terminations and requires three LIUs and three vertical troughs.

Install the SFT cabinet as follows:

- Install a single alarm cable, running it to an ACU the interface cabinet. The cabinet is tampered. Review the SNL/CA Security Department standards for details on the NEMA cabinet sizes, troughs, and LIUs.
- Instruct the installation contractor to terminate, test, and certify the dedicated 12-fiber (or larger) Systimax TeraSPEED outdoor trunk fiber-optic cable (5024 012A WXBK) entering the cabinet to the current telecommunication standards.

11.6.5 Security Control Box Cabinet

The Security Control Box (SCB) is a locked, tampered cabinet. For the SCB cabinet, specify the appropriate cabinet:

- For indoor, semi-flush applications, 12- x 12- x 6-inch NEMA 1 cabinet (Hoffman A12N126). Fire-rated wall blocking of semi-flush cabinets may be required. All semi-flush applications must be in compliance with International Building Code (IBC), Section 712 3.2.
- For indoor, surface-mount applications, 12- x 12- x 4-inch NEMA 1 cabinet (Hoffman A12N124).

Install the SCB cabinet as follows:

- Install an SCB at all door and hatch locations, and mount it on the secure side of the door.
- Secure the SCB with a tamper switch mounted inside the cabinet.
- Make conduit penetrations into the SCB cabinet in approved locations. (Review the SNL/CA construction standards for more information.)
- Run conduit from the hardware at a particular door (for example, door strikes, BMSs, REXs, card readers, and connections to the ACU associated with the door) to the SCB. If two readers (such as inbound and outbound) are required at a single door, mount two SCBs in a side-by-side or top-to-bottom configuration.
- Lock the SCB with an administrative (Level IV) lock. The SNL/CA Security Department provides or approves the lock.

11.6.6 Request-to-Exit Cabinet

The Request-to-Exit (REX) cabinet is a tampered, locked cabinet installed at all door locations. For the REX cabinet, specify a 6- x 6- x 4-inch NEMA 1 cabinet (Hoffman A6N64).

Install the REX cabinet as follows:

- Mount the REX cabinet within 3 feet of the BMS to allow the whips attached to the BMS to be terminated inside the REX cabinet.
- Run conduit from the REX cabinet for the door associated with the cabinet to the SCB.
- Lock the REX cabinet with an administrative (Level IV) lock. The SNL/CA Security Department provides or approves the lock.

11.6.7 Card Reader Mounting Box

For a card reader, specify the appropriate box:

- For flush-mount applications, a 4-square-deep handy-box with a 2-gang mud ring.

Install the carder reader as follows:

- Run ¾-inch conduit from the SCB to the card reader box. For a double-reader configuration, run ¾-inch conduit from an SCB to the associated card reader box.

11.6.8 Approved Cables

"A Cable" must be used from the ACU to field devices (for example, RRE and RIM). Specify a RS-485, 22AWG 2 pair & 1pair 18AWG: Belden 8446. Limit the maximum distance to 4,000 feet or 1,219 meters. Only two of these cables may be connected to a given ACU—one for each reader port.

- Start this cable at the ACU and go in a one-way serial path to the field devices, up to a maximum of 8 devices per reader port being used. For a total of 16 devices
- Choose the routing to minimize the cable distances.
- Using the maximum cable distance can cause resistance problem and is not recommended for any line with more than 2 devices.

"B Cable" must be used for low-voltage power. Specify 18 AWG, unshielded, 2-conductor: Belden 9409.. Install and use the cable as follows:

- Limit the maximum distance to 1,000 feet or 305 meters.
- Use this cable to provide power to door strikes and field devices. Do not use this cable for sensors, REXs, or door contacts.
- Route a "B cable" with the "A cable" in the same serial fashion as power to the field devices. Route an additional "B cable" from the door strike power supply to each door strike.

"C Cable" must be used for door contacts, sensors, and REX devices. Specify 22 AWG, shielded, 4-conductor, Belden 8723. The cable must be limited to the maximum distance of 1,000 feet or 305 meters.

"D Cable" must be used for cables longer than 25 feet from the SCB to the keypad and card readers. Specify 22 AWG, overall foil shield, 10-conductor: Belden 9946. Install and use the cable as follows:

- Limit the maximum distance to 500 feet or 152 meters.
- Use this cable for RRE to Apti-Q connections.

"E Cable" must be used for cables less than 25 feet from the SCB to the keypad and modular telephone cable for the card readers. Specify 26 AWG, unshielded, 8-conductor, silver satin: Belen RI-47853, Alpha 6419 or Manhattan M39132. Install and use the cable as follows:

- Limit the maximum distance to 25 feet or 8 meters.
- Use this cable for RRE to RMS-10/K-11 connections.

"F Cable" must be used for the standard installation of optical-fiber panel communications. This cable is the standard cable from the Main Distribution Room (MDR) to the IDR. Contact SNL/CA Security Department for confirmation of Specify a single-mode, outdoor, loose-tube, 12-fiber, yellow-jacket Systimax TeraSPEED cable (O-012-LN-8W-F12NS). For a nonstandard installation, select the appropriate product from the following table. Substitutions and "or equal" **are not allowed**. For a building with more than two ACUs, contact the SNL/CA Security Department. The use of more than two ACUs may require larger fiber counts.

"G Cable" must be used for optical-fiber panel communications. Specify a single-mode, indoor, loose-tube, 6-fiber, yellow-jacket Systimax TeraSPEED (O-006-LN-8W-F06NS). For a nonstandard installation, select the appropriate product from the following table. Substitutions and "or equal" **are not allowed**.

"H Cable" must be used for plenum-rated, indoor panel communications and SFI to ACU communication. Specify 24 AWG, 4-pair, category 6E. The cable must be limited to the maximum distance of 328 feet or 100 meters.

In addition to the requirements described above, use the following tables to determine the appropriate optical fibers and terminations. Only the following SYSTIMAX products are approved for use at SNL/CA.

Table 11-1 Approved Optical Fibers and Terminations

Purpose	Systimax Product	Product No.	Material ID	Fiber Count
Single mode: Indoor	TeraSPEED Rise (indoor-rated cable)	R-006-DS-8W-FSUYL	760004424	6
		R-012-DS-8W-FSUYL	760004440	12
		R-024-DS-8W-FSUYL	760018515	24
Single mode: Outdoor	TeraSPEED Dielectric (outdoor, loose-tube cable)	O-006-LN-8W-F06NS	760002584	6
		O-012-LN-8W-F12NS	760002592	12
		O-018-LN-8W-	760002600	18

Purpose	Systimax Product	Product No.	Material ID	Fiber Count
		F12NS		
		O-024-LN-8W-F12NS	760002618	24
		O-036-LN-8W-F12NS	760002626	36
		O-048-LN-8W-F12NS	760002634	48
		O-072-LN-8W-F12NS	760002642	72
		O-096-LN-8W-F12NS	760002659	96
Wall Mount Optical Termination Panel	LIU Shelves (connector quantity of 24)	200A LIU	105535926	
LIU Panels	LIU Panel (for 6 Simplex St adapters)	10a (ST)	104141858	
	100a3 and 200a LIU (for 6 Simplex Sc adapters)	10SC1 Panel	106371800	
Vertical Trough	Vertical Trough	2AB	106295520	
ST Single mode Terminations	STII+ Connector	SFC-STU	700011067	
	St Adapter (with hex mounting nut)	SFA-ST01	700011133	
SC Single mode Terminations	BTW SC-A Connector (for 0.9 mm buffered fiber)	SFC-SFC-09-BRL	700007112	
	TeraSPEED SC Simplex Adapter	SFA-SC01-BL	700004807	

11.7 Grounding Requirements

All grounding and bonding activities must be performed in accordance with the grounding and bonding section of SNL Standard Specification, 16001, *Electrical Work.*

11.8 Vehicle Gates

Vehicle gate standards require paired vehicle-in and vehicle-out gates. Each vehicle lane must have two gate arms and one swing gate. The SNL/CA Facilities Management takes responsibility for gates and turnstiles and their designs and locations.

NOTE Use only one gate arm for PPA gates. Review the SNL/CA Security Department standard drawings for details on mounting, distances, and configurations.

Install a vehicle gate as follows:

- Coordinate all proposed vehicle gate locations with the SNL/CA Security Department prior to design and construction.
- Specify Door King products for the gate arm (1601-080) and swing gate operator (6300-084), per SNL/CA Security Department standards for LA gates.
- For the inbound lane, use two sets of badge readers mounted on a protected stand.
- For the outbound lane, use two sets of badge readers mounted on a protected stand.

  NOTE Outbound readers are not used for PPA gates.
- Install protection loops, per standard drawings, to provide proper operation of the gate system, for a single vehicle or a vehicle with a trailer.

11.9 Standby Power

Technical Security Systems generally provides standby power as part of the standard hardware, which comes with 12-volt batteries as part of the system backpanels. The only current application that requires standby power beyond regular hardware is the vehicle gate, which is described in "Vehicle Gates," and the network and communication hardware, which is covered by UPS and corporate generator power.