U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
OFFICE OF MISSION SUPPORT REVISED DECEMBER 8, 2020

EPA FACILITIES MANUAL: VOLUME 2

ARCHITECTURE AND ENGINEERING GUIDELINES

The photo on the previous page is of the atrium in the EPA Region 8 Office in Denver, Colorado. The atrium acts as an informal gathering place for occupants of the building, and helps reduce energy use, because it is a partially conditioned space that acts as a thermal buffer for the building as a whole. Fabric sails reflect light down into the atrium, shield occupants on the atrium's upper floors from the glare of direct sun and minimize solar heat gain.

TABLE OF CONTENTS

This page intentionally left blank.

1. General Requirements

1.1 Overview

1.1.1 EPA Facilities Manual

These *Architecture and Engineering Guidelines* (referred to hereafter as the A&E Guidelines) are a volume of the *EPA Facilities Manual*. The *EPA Facilities Manual* is composed of four distinct, yet complementary, volumes for planning, designing and managing EPA facilities.

- Volume 1: The *Space Acquisition and Planning Guidelines* contain information on space planning, space estimation, environment, materials, furniture, process and maintenance. The EPA Office of Administration developed this document to help EPA facility managers, space managers, and line personnel plan and use their space.
- Volume 2: *Architecture and Engineering Guidelines* provide requirements and guidance for facilities planning, engineering, architecture, and management professionals in the design, construction, renovation, and alteration of EPA facilities.
- Volume 3: The *Safety and Health Manual: Safety and Health Requirements* (referred to hereafter as the EPA Safety Manual) outline safety and health considerations for owned or leased EPA facilities. The Safety Manual's goal is to maintain a safe and healthful workplace that protects against injury, illness and loss of life.
- Volume 4: The *Safety, Health and Environmental Management Manual: Environmental Management Guidelines* (referred to hereafter as the EPA Environmental Management Manual) establish environmental specifications to be addressed by designers and managers of EPA facilities and related building systems.

1.1.2 Purpose

The primary purpose of these A&E Guidelines is to establish a consistent, agencywide level of quality and excellence in the planning, design and construction of all EPA facilities-related projects. These A&E Guidelines are also intended to be used as resources for developing construction documents for public bidding and/or the award of construction contracts to meet relevant building code and EPA facilities requirements. They are not intended to deter use of more stringent or greater performance criteria. Architects, engineers, contractors and other professionals supporting EPA facility projects shall determine any additional requirements not covered in these A&E Guidelines for their projects. It is the responsibility of these professionals to verify which requirements must be attained for a project and to develop a strategy for achieving the relevant requirements.

1.1.3 Responsible Parties

For the purposes of this document, the following entities are defined as follows:

- **EPA Project Manager:** For projects at EPA-owned buildings, the EPA Project Manager is the Contracting Officer's Representative (COR). For projects at General Services Administration (GSA)-owned or GSA-leased buildings, the EPA Project Manager is the designated EPA point-of-contact for the project. The EPA Project Manager is responsible for managing the project and has the authority to delegate responsibilities to qualified individuals.
- **Project Architect/Engineer (A/E):** The Project A/E refers to the architecture/engineering firm and any subcontractors hired by that firm who are contractually responsible for the design of the project and for production of construction contract documents.
- **Construction Contractor:** The Construction Contractor is the general contracting firm and any subcontractors hired by that firm who are contractually responsible for the construction of the project.

Adherence to the A&E Guidelines does not relieve the Project A/E and Construction Contractor of any of their responsibilities as professionals. The Project A/E personnel involved in the design of an EPA-owned and/or operated laboratory, office, storage or other facility shall be licensed professionals in their fields of expertise and shall be experienced in the design of such facilities. They will be required to ensure that all portions of the project comply with all established applicable regulations, codes, standards, references and guidance, as well as the provisions of these A&E Guidelines.

1.1.4 Codes, Standards and References

Appendix A of these A&E Guidelines includes a list of required regulations, codes, standards, references and guidance. Appendix A is not all-inclusive, however, and omission from this list does not release the Project A/E or Construction Contractor from meeting established applicable regulations, codes, standards, references and guidance.

Citations of regulations, codes, standards, references or guidance within these A&E Guidelines shall be assumed to refer to the most recent edition at the time of contract award. Any publication dates specifically stated in the A&E Guidelines reflect the version in use when the A&E Guidelines were written and published. When using these A&E Guidelines, the user shall verify that the documents referenced are the most recent and have not been superseded.

State and Local Laws

Facilities built on federal property are exempt from state and local building codes. It is the EPA's intention, however, to comply with state and local building codes to the maximum extent practicable.

In accordance with the United States Code, Title 40, Section 3312 (40 U.S.C. 3312), buildings constructed or altered by a federal agency shall consider all requirements (except procedural requirements) of the following state and local laws, which would apply to the building if it were not constructed or altered by a federal agency:

- Zoning laws.
- Laws relating to landscaping, open space, minimum distance of a building from the property line, maximum height of a building, historic preservation, esthetic qualities of a building, and other similar laws.

Per 40 U.S.C. 3312, the EPA and Project A/E shall consult with the appropriate state and local officials when preparing building plans and shall permit the officials to review plans and conduct inspections during building construction or alteration. The EPA and its contractors are not required to pay any amount for any state or local action, including reviewing plans, carrying out inspections, issuing building permits and making recommendations. The EPA is required to give due consideration to recommendations from state and local officials but has the final authority to accept or reject any recommendations on EPA-owned buildings.

Leased buildings, not owned by another federal agency, are subject to state and local laws and building code requirements.

Conflicts

In cases of conflict between codes, standards or other requirements, the most stringent, technically appropriate criteria shall apply. Where it is unclear which set of requirements is applicable, consult the EPA Project Manager for direction.

1.2 Safeguarding and Dissemination of Controlled Unclassified Information

1.2.1 Marking Controlled Unclassified Information

Documents that contain building information must be reviewed by the EPA to identify any Controlled Unclassified Information (CUI), before the original or any copies are disseminated to any other parties. If CUI is identified, the EPA Project Manager may direct contractors to imprint or affix CUI document markings to the original documents and all copies before dissemination.

1.2.2 Authorized Recipients

Building information considered CUI must be protected with access strictly controlled and limited to those individuals having a need to know such information. Those with a need to know may include federal, state, and local government entities and nongovernment entities engaged in the conduct of business on behalf of or with the EPA. Nongovernment entities may include architects, engineers, consultants, contractors, subcontractors, and others submitting an offer or bid to the EPA or performing work under an EPA contract or subcontract. Contractors must provide CUI building information when needed for the performance of official federal, state and local government functions, such as for code compliance reviews and for the issuance of building permits. Public safety entities such as fire and utility departments may require access to CUI building information on a need-to-know basis. This paragraph must not prevent or encumber the dissemination of CUI building information to public safety entities.

1.2.3 Dissemination of CUI Building Information

By Electronic Transmission

Electronic transmission of CUI outside of the EPA firewall and network must use sessions (or alternatively file encryption). Sessions (or files) must be encrypted with an approved National Institute of Standards and Technology (NIST) algorithm, such as Advanced Encryption Standard (AES) or Triple Data Encryption Standard (3DES), in accordance with Federal Information Processing Standards Publication (FIPS) 140-2, *Security Requirements for Cryptographic Modules*. Encryption tools that meet FIPS 140-2 are referenced on the NIST website: http://csrc.nist.gov/groups/STM/cmvp/documents/140-1/1401vend.htm. All encryption products used to satisfy the FIPS 140-2 requirement should have a validation certificate that can be verified at http://csrc.nist.gov/groups/STM/cmvp/validation.html#02. (Not all vendors of security products that claim conformance with FIPS 140-2 have validation certificates.) Contractors must provide CUI building information only to authorized representatives of federal, state, and local government entities and firms currently registered as "active" in the System for Award Management (SAM) database at https://www.acquisition.gov that have a need to know such information. If a subcontractor is not registered in SAM and has a need to possess CUI building information, the subcontractor shall provide to the contractor its Data Universal Numbering System (DUNS) number or its tax identification number and a copy of its business license.

By Non-Electronic Form or on Portable Electronic Data Storage Devices

Portable electronic data storage devices include but are not limited to CDs, DVDs and USB drives. Non-electronic forms of CUI building information include paper documents.

- **By Mail:** Utilize only methods of shipping that provide services for monitoring receipt of delivery, such as track and confirm, proof of delivery, signature confirmation or return receipt.
- **In Person:** Contractors must provide CUI building information only to authorized representatives of federal, state, and local government entities and firms currently registered as "active" in the SAM database that have a need to know such information.

Record Keeping

Contractors must maintain a list of the federal, state, and local government entities and the firms to which CUI is disseminated. This list must include, at a minimum, all of the following information:

- The name of the federal, state, or local government entity or firm to which CUI has been disseminated.
- The name of the individual at the entity or firm that is responsible for protecting the CUI building information, with access strictly controlled and limited to those individuals having a need to know such information.
- Contact information for the named individual.
- A description of the CUI building information provided.

Once work is completed, the contractor must collect all lists maintained in accordance with this paragraph, including those maintained by any subcontractors, and submit them to the EPA Project Manager.

1.2.4 Retaining CUI Documents

CUI building information (both electronic and paper formats) must be protected, with access strictly controlled and limited to those individuals having a need to know such information.

1.2.5 Destroying CUI Building Information

When no longer needed, CUI building information must be destroyed such that the marked information is rendered unreadable and incapable of being restored, or returned to the EPA Project Manager, in accordance with NIST Special Publication 800-88, *Guidelines for Media Sanitization*. If CUI building information is not returned to the EPA Project Manager, examples of acceptable destruction methods for CUI building information include burning or shredding hard copy; physically destroying portable electronic storage devices such as CDs, DVDs and USB drives; deleting and removing files from electronic recycling bins; and removing material from computer hard drives using a permanent-erase utility such as bit-wiping software or disk crushers.

1.2.6 Notice of Disposal

The contractor must notify the EPA Project Manager that all CUI building information has been destroyed or returned to the EPA Project Manager by the contractor and its subcontractors in accordance with Section 1.2.5 above, with the exception of the contractor's record copy. This notice must be submitted to the EPA Project Manager at the completion of the contract in order to receive final payment.

1.2.7 Incidents

All improper disclosures of CUI building information must be reported immediately to the EPA Project Manager. If the contract provides for progress payments, the EPA Project Manager may withhold approval of progress payments until the contractor provides a corrective action plan explaining how the contractor will prevent future improper disclosures of CUI building information. Progress payments may also be withheld for failure to comply with any provision in this Section 1.2 until the contractor provides a corrective action plan explaining how the contractor will rectify any noncompliance and comply with this Section 1.2 in the future.

1.2.8 Subcontracts

The contractor must insert the substance of this Section 1.2 in all subcontracts.

1.3 Design Process

The EPA is a strong proponent of integrated design. Integrated design requires that all stakeholders evaluate the project objectives and building design to achieve synergies that result in a more efficient, cost-effective, functional, safe and sustainable building.

1.3.1 Pre-Design Process

The pre-design process will be conducted by the EPA and will generate various planning documents, evaluations and reports.

Program of Requirements

The EPA Project Manager and representatives from the EPA's Real Property Services Division, Safety and Sustainability Division, and Security Management Division, as well as the Director and EPA Facility Manager for the project location, as appropriate, will coordinate on the development of the Program of Requirements (POR) that includes the following:

- An overview of the project scope, objectives, requirements and performance criteria.

- A description of facility spaces to be constructed or renovated, area requirements for interior spaces, and area requirements for exterior spaces, if applicable.
  - Quantitative and qualitative program requirements for each EPA component, including space identification, sizes, functional requirements and adjacencies.
  - Room data sheets for all facility spaces, developed in accordance with the requirements of Volume 1, *Space Acquisition and Planning Guidelines*, including hazardous materials inventories and equipment data sheets, where applicable.
- Energy and water efficiency measures that shall be included in the project. The EPA Project Manager and representative EPA staff shall review the energy and water efficiency measures recommended in prior energy and water assessments to determine which measures to include in the project. The EPA may request that the Project A/E conduct further analyses on the feasibility and cost-effectiveness of the selected energy and water efficiency measures.
- Building systems and technologies for which the Project A/E shall conduct life cycle cost analyses (LCCAs) to determine cost-effective and energy and water efficient design solutions, such as:
  - Building envelope design alternatives.
  - Structural design alternatives.
  - Heating, ventilation and air conditioning (HVAC) design and equipment alternatives.
  - Electrical design and equipment alternatives.
  - Data center design alternatives.
  - Renewable energy technologies.

The POR will be provided to the Project A/E with the statement of work. The Project A/E will be responsible for ensuring that the requirements in the POR, as well as these A&E Guidelines, are properly addressed and incorporated into the design and construction phases of the project. All POR documents shall comply with the U.S. Government Accountability Office's *GAO Cost Estimating and Assessment Guide*.

GreenCheck

During this planning phase, the EPA Project Manager is required to initiate a pre-design phase GreenCheck to ensure the project's scope, planning documents, and statement of work adhere to federal sustainability requirements, including, but not limited to, the *Guiding Principles for Sustainable Federal Buildings*. The form will be completed in coordination with the EPA Safety and Sustainability Division. For projects that meet the eligibility criteria (detailed in the form), the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, must update the GreenCheck form after each design submittal—15, 35, 65, 95 and 100 percent—and at substantial completion.

Commissioning Authority

The EPA will separately contract for a Commissioning Authority during the pre-design process. The selected Commissioning Authority will be involved in the development of the POR and will review the Basis of Design (BOD) and all design submittals to ensure the design is achieving the POR. The EPA's commissioning process is documented in the *EPA Building Commissioning Guidelines*.

1.3.2 Kickoff Meeting, Design Charrette and Feasibility Analyses

Kickoff meeting attendees will include the Project A/E, representation from the EPA's Real Property Services Division, Safety and Sustainability Division, Security Management Division, and Commissioning Authority, as well as the Director and EPA Facility Manager for the project location, as appropriate. The intent of the kickoff meeting is to:

- Review the EPA's POR for the project to ensure all parties understand the project goals and requirements.

- Highlight critical systems, components and metrics that determine project success.
- Have the Project A/E present their design approach.
- Agree to submission and communication protocols.
- Discuss project schedule and milestones.

The EPA will notify the Project A/E if the project complexity necessitates a design charrette. When held, the charrette will be attended by representatives of the same organizations listed above for the kickoff meeting. As part of the integrated design process, the design charrette is used to inform all stakeholders of federal requirements relevant to the project and catalyze schematic design. The Project A/E may be required to develop and present to the entire team design solutions for focused areas, such as laboratory spatial needs. The result of the charrette is greater clarity of the POR, programming, materials and methods, and special systems related to project design development and construction.

Prior to the development of the BOD, the Project A/E may need to conduct additional feasibility analyses, including the analyses discussed in Chapter 3, Planning and Siting.

1.3.3 Basis of Design

The Project A/E shall submit a BOD that addresses all requirements presented in the POR, captures decisions made during the design charrette, and documents assumptions being used to develop the design. The Project A/E shall update the BOD throughout the design to track changes in the project's direction, but shall ensure it remains compliant with the latest POR. The BOD may be captured in narrative form in early submission milestones, but shall be augmented with calculations, diagrams and the building information model (BIM) during later milestones.

1.3.4 Design Submittals Overview

The Project A/E shall submit required construction drawings, specifications, cost estimates and design analyses/calculations to the EPA Project Manager at interim milestones of development. Typically, submittals are required at the 15, 35, 65, 95 and 100 percent milestones. Not all projects, however, will require submission at each of the milestones. If a milestone is omitted, the EPA reserves the right to require the Project A/E to provide specific submittals that would have otherwise been delivered at that milestone. Submittals, including specifications and design drawing notations, must follow Construction Specifications Institute (CSI) MasterFormat. A list of the recommended Division 00, 01 and 02 specification sections is in Appendix B of these A&E Guidelines.

At each milestone, the EPA will go through its internal review process and provide comments to the Project A/E, as appropriate. As needed, the Project A/E may request a meeting(s) to clarify any comments or resolve any conflicts. The Project A/E must ensure all comments are satisfactorily addressed or resolved and are incorporated in the next phase of design. All comments shall be addressed/resolved prior to submitting the design package for bidding.

With each milestone, the EPA with its Commissioning Authority will update the POR, as necessary.

1.3.5 15 Percent Submittal (Concept/Schematic Design)

The 15 percent submittal ensures that the Project A/E demonstrates an understanding of the scope of the project and will adhere to project criteria, formats and conventions. At this milestone, the Project A/E will submit, for example:

- Updated BOD.
- Code analysis, identifying all applicable regulatory standards and key criteria that will affect the design.
- Vicinity plan, showing existing and new topography, stormwater flows, utilities, access roads, parking, site circulation and relationships to other buildings.
- Photographs of the site and surroundings.

- Conceptual building model with massing studies consistent with BIM Level of Development 100. The building model must be tied into the energy model.
- Exterior elevations, showing fenestration and exterior building materials.
- Single-line floor plans, showing all walls, openings, rooms and built-in features.
- Building sections and typical wall sections, showing floor-to-floor heights.
- Facility organization plans and/or sections, showing main circulation paths and the locations of shared and specialized spaces.
- Space tabulation by room, indicating net square footage, architectural treatments and utilities.
- Sustainability design plan, detailing the approach to meeting the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements, including laws and executive orders.
- Climate and weather data from the National Weather Service or local weather service with seasonal wind data (presented as an annual wind rose) and solar orientation data.
- Energy model baseline simulations and preliminary calculations, showing the design will meet the energy performance levels required by the *Guiding Principles for Sustainable Federal Buildings*, Code of Federal Regulations (CFR) Title 10 Part 433 and any other federal mandates.
- LCCAs for building systems and technologies as requested in the POR. Refer to Section 1.5, Energy and Water Efficiency – Life Cycle Cost Analyses and Simulation Modeling, within these A&E Guidelines for LCCA methodology requirements.
- Preliminary daylighting analysis (only for new construction and major renovation projects).
- Facility resiliency analysis, specifying design elements to mitigate potential weather impacts. The Project A/E shall coordinate with the EPA subject matter expert (SME) on resiliency to obtain any existing resiliency assessments for the facility.
- Preliminary metering analysis. The Project A/E shall coordinate with the EPA SME on metering to determine the (1) utilities and systems that have meters or need new meters; and (2) requirements for communicating with the building's control systems and the EPA's enterprise-level advanced metering software system.
- Preliminary backup power analysis, identifying backup power needs and fuel storage system requirements and location.
- Order of magnitude cost estimate based on UniFormat, detailed to Level 3 group elements, reflecting the cost of the intended project and the cost of alternate schemes/solutions presented, including the cost for providing expansion contingency.

As part of reviewing the Project A/E's submission under this milestone, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a 15 percent phase GreenCheck form. Where the design submission is not on track for meeting the federal sustainability requirements included in the form, the EPA Project Manager shall provide comments to the Project A/E indicating which aspects of the design are not in compliance.

1.3.6 35 Percent Submittal (Design Development)

The 35 percent submittal includes design development documents and supporting design calculations to clearly show the adequacy of project design and functional arrangements. This submittal includes, for example:

- Updated BOD.

- Full code analysis, identifying all applicable regulatory standards and key criteria that will affect the design, including construction type, occupancy, occupant loads, life safety diagrams for fire ratings/separations and egress, plumbing fixture requirements, material requirements, etc.
- Site development plans, delineating all buildings in the area, proposed parking locations, roads, sidewalks, curbing, fencing, landscaping, stormwater management system, and routing of water, sewer, gas, and other utilities.
- Security plan, describing the methods, procedures and measures that will be used to maintain site security.
- Preliminary site stormwater calculations, determining the rainfall intensity (in inches) and runoff associated with the 95th percentile storm, consistent with the EPA *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. The site drawings and calculations shall show how low impact development stormwater management strategies are managing the rainfall onsite and preventing the offsite discharge of precipitation from all rainfall events less than or equal to the 95th percentile rainfall event.
  - In addition, runoff quantities that exceed the 95th percentile storm shall be provided where required by local flood control ordinances and codes (and in conformance with those ordinances/codes).
- Refined building model, identifying all major systems and spaces consistent with BIM Level of Development 200. The building model must be tied into the energy model.
- Further developed massing in context with adjacent site, topography and buildings.
- Architectural plans, showing complete functional layout, room designations, critical dimensions, all columns and built-in equipment for each building section.
- Reflected ceiling plans.
- Preliminary layout for furniture, fixtures and equipment.
- Preliminary door schedule, clearly indicating the hardware, lockset function for each door and any security infrastructure required.
- Preliminary schedule of finishes, clearly indicating environmental attributes of each material (e.g., volatile organic compound levels, recycled content).
- Updated analysis of compliance with the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements.
- Updated energy model with updated energy use calculations, input parameters and output data.
- Updated and additional LCCAs, as warranted.
- Updated daylighting calculations.
- Life safety plans, showing fire subdivisions, fire separation ratings throughout the building, occupant load calculations and exit capacity calculations.
- Water supply analysis, evaluating the available water supply for fire department use and calculating the anticipated demand of a facility to establish the minimum water supply required (provide appropriate supporting calculations and proposed design options and/or alternatives for consideration).
- Preliminary riser diagram for communication and fire alarm systems.
- Plumbing plans, showing proposed fixture locations and basic riser diagrams.
- Mechanical plans, delineating proposed layout of all major items of mechanical equipment, including the backup power fuel storage system.

- Basic outline of control system requirements (e.g., materials, methods, sequence of operation). Preliminary one-line or ladder diagrams for the HVAC system and HVAC control system will be submitted as part of the electrical package. (See electrical plans bullet below.)
- Electrical plans, showing proposed electrical service and distribution array (preliminary one-line or ladder diagrams), lighting fixture patterns, receptacle locations, and backup power.
- Preliminary one-line diagram of proposed metering network that includes the location of meters and their connection to remote terminal units (if necessary for communicating with the EPA's enterprise-level advanced metering software system) and building automation system (BAS).
- Specifications table of contents for all applicable materials; types of work; and architectural, structural, mechanical, electrical, and plumbing systems.
- Itemized cost estimates, identifying all intended work, based on UniFormat, detailed to Level 4 group elements.
- Preliminary proposed project phasing approach (if necessary).

As part of reviewing the Project A/E's submission under this milestone, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a 35 percent phase GreenCheck form. Where the design submission is not on track for meeting the federal sustainability requirements included in the form, the EPA Project Manager shall provide comments to the Project A/E indicating which aspects of the design are not in compliance.

1.3.7 65 Percent Submittal (Construction Documents)

The 65 percent submittal includes contract documents and supporting materials that clearly show the development of the project at the 65 percent milestone. The objective is to provide the EPA with sufficient drawings, cost estimates and specifications to evaluate the Project A/E's adherence to detail and systems criteria, to review coordination between disciplines, and to ensure that comments made during previous reviews were understood and incorporated. The 65 percent submittal shall include, for example:

- Updated BOD.
- Completed title sheet, drawing index and legend sheets.
- Updated code analysis, identifying all applicable regulatory standards and key criteria that will affect the design.
- Detailed site and utility plans.
- Landscaping plans, clearly illustrating compliance with species selection and water use reduction requirements.
- Updated stormwater calculations.
- Detailed building model, identifying all major and minor systems and spaces consistent with BIM Level of Development 300. The building model must be tied into the energy model.
- Developed roof plan and exterior elevations, building sections and wall sections.
- Detailed building floor plans with all walls, partitions, dimensions, door and window schedules and details, plumbing fixtures, and fixed equipment or items (e.g., fume hoods, sinks, cabinets).
- Composite floor plans (when applicable), showing construction phasing.
- Revised reflected ceiling plan.
- Developed layout and schedule of furniture, fixtures and equipment.

- Updated door schedule, clearly indicating the hardware, lockset function for each door and any security infrastructure required.
- Updated schedule of finishes, clearly indicating environmental attributes of each material. Provide digital architectural finish boards and visualization for all major interior design elements.
- Updated analysis of compliance with the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements.
- Updated energy model with updated energy use calculations, input parameters and output data.
- Updated and additional LCCAs, as warranted.
- Updated daylighting calculations, if design changes have affected the results.
- Completed fire protection/life safety plans, including fire sprinkler/standpipe calculations, fire alarm drawings and a detailed description of the fire alarm system. Detailed calculations and description of any fire suppression or smoke control/exhaust system and its controls shall also be provided, including activation, interlocks with the HVAC system, and connection to detection and alarm systems.
  - Sprinkler demand analysis: For design-bid-build projects, provide proposed system layout with hydraulic sprinkler calculations, as required in National Fire Protection Association (NFPA) 13 or other applicable criteria, of the expected demand area(s) to reflect the system demand (calculations that approximate the demand and pressure requirements are not acceptable).
- All design listings, reference numbers and exact construction details for fire-rated assemblies. The appropriate detail must be provided on the architectural plans for all fire-rated assemblies and systems used in the construction of the building, including the descriptive listings of all products used in the assemblies and systems.
- Detailed hazardous material inventory statement, including, but not limited to, product name, Chemical Abstracts Service (CAS) number, classification, storage location, storage method, NFPA 704 ratings and the supporting Safety Data Sheets.
- Updated plumbing plans with a detailed description of the plumbing systems, including calculations for the sizing of the following: domestic hot and cold water, waste and vent, natural and liquefied petroleum gases, vacuum, compressed air, distilled and deionized water, medical gases, and other specialty systems. Clearly illustrate plumbing fixture compliance with WaterSense,® ENERGY STAR® and Federal Energy Management Program (FEMP) product specification requirements. Also, illustrate compliance with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 189.1 Sections 6.3.2 (Building Water Use Reduction-Mandatory Provisions), 6.4.2 (Building Water Use Reduction-Prescriptive Option) and 6.4.3 (Special Water Features-Prescriptive Option).
- Updated mechanical plans with a detailed description of mechanical system design, including equipment and refrigerants. Clearly illustrate equipment compliance with ENERGY STAR and FEMP product specification requirements.
- Detailed calculations of heating and cooling loads, piping, ductwork, and equipment sizing associated with the HVAC system, including calculations illustrating compliance with ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy,* and ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*.
- Detailed control system requirements (e.g., materials, methods, sequence of operation, sensors [type, accuracy, precision], and control valves), including:
  - A description of, and vendor specifications for, the BAS. (Refer to Chapter 9, Building Automation Systems, within these A&E Guidelines for detailed requirements of the BAS.)

- Descriptions of air inflow and exhaust balancing, system response time, and turn-down capacity of major equipment and systems, including (1) ventilation air ducts and dampers; and (2) hydronic system piping and associated valves.

- Basic ladder diagrams and temperature control schematics, indicating remote sensors, panel mounted controllers and thermostats.
- Updated electrical plans with a one-line power diagram and detailed description of electrical system design, including lighting systems, wiring systems, lighting protection system, grounding, basic characteristics of panel boards (including short circuit and voltage drop calculations), metering, electrical schedule, and fire alarm system (including battery calculations). Clearly illustrate equipment compliance with ENERGY STAR and FEMP product specification requirements.
- Detailed description of the advanced metering system, including vendor specifications for building-level and submeters.
- Documentation of manufacturer's operations and maintenance (O&M) requirements for all specified metering hardware.
- Detailed specifications for all materials, systems and equipment.
- Building recycling collection plan with floor plans annotating areas for collecting reusable, recyclable and compostable materials.
- Detailed cost estimate, with unit prices broken down into labor, materials and equipment, using quantity take-offs in CSI MasterFormat that corresponds to UniFormat Level 4.
- Updated proposed project phasing approach (if necessary).

The Project A/E shall coordinate the submission of the 65 percent submittal with the draft Commissioning Plan developed by the EPA's Commissioning Authority for the project.

As part of reviewing the Project A/E's submission under this milestone, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a 65 percent phase GreenCheck form. Where the design submission is not on track for meeting the federal sustainability requirements included in the form, the EPA Project Manager shall provide comments to the Project A/E indicating which aspects of the design are not in compliance.

1.3.8 95 Percent Submittal (Pre-Bid)

The 95 percent submittal shall include contract documents and supporting materials that are considered near final. This submittal includes, for example:

- Updated BOD.
- Updated code analysis, identifying all applicable regulatory standards and key criteria that will affect the design.
- Final stormwater calculations.
- Detailed building model, identifying all major, minor, and detailed systems and spaces, and indicating equipment, finishes, and furnishings consistent with BIM Level of Development 350. The building model must be tied into the energy model.
- Contract drawings and specifications that are complete and coordinated for all disciplines.
- Final digital architectural finish boards.
- List of proprietary items, long lead-time items, and/or items that because of their uniqueness, rareness, and/or critical tolerance in manufacture and/or installation require scrutiny during construction.

- Updated analysis of compliance with the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements.
- Final energy model with energy use calculations, input parameters and output data.
- Final LCCAs.
- Final daylighting calculations.
- Final calculations for all systems and equipment, including engineering calculations.
- Final energy control system drawings, including the drawing index, control system legend, valve schedule, damper schedule, control system schematic and equipment schedule, sequence of operation and data terminal strip layout, control loop wiring diagrams, motor starter and relay wiring diagram, communication network and block diagram, and direct digital control (DDC) panel installation and block diagram.
- Final advanced metering system drawings and specifications. Advanced metering system must be integrated with the energy control system.
- Detailed cost estimate, with unit prices broken down into labor, materials and equipment, using quantity take-offs in CSI MasterFormat that corresponds to UniFormat Level 5.
- Updated proposed project phasing approach (if necessary).

As part of reviewing the Project A/E's submission under this milestone, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a 95 percent phase GreenCheck form. Where the design submission is not on track for meeting the federal sustainability requirements included in the form, the EPA Project Manager shall provide comments to the Project A/E indicating which aspects of the design are not in compliance.

1.3.9 100 Percent Submittal (Bidding Documents)

The 100 percent submittal shall include contract documents and supporting materials that are considered biddable documents. With this submittal, the Project A/E shall provide:

- Detailed building model, identifying all major, minor, and detailed installation requirements for all systems and spaces, and indicating equipment, finishes, and furnishings consistent with BIM Level of Development 400.
- All final drawings, specifications, and cost estimates signed, stamped, and ready for solicitation for bids.
- Final proposed project phasing approach (if necessary).
- Manufacturers' catalog cuts, engineering supporting documents (including calculations), and published data of major items specified and used as the basis of the design.
- A detailed submittal log, in accordance with the Division 01 specifications, to be utilized during construction management.
- Updated documentation of compliance with the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements.

As part of reviewing the Project A/E's submission under this milestone, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a 100 percent phase GreenCheck form. Where the design submission is not on track for meeting the federal sustainability requirements included in the form, the EPA Project Manager shall provide comments to the Project A/E indicating which aspects of the design are not in compliance.

1.3.10 Addenda (Design Revisions)

As part of the integrated design approach, the Construction Contractor's requests for information may result in the need for additional coordination and clarification and the issuance of design addenda (by the Project A/E) to ensure scope, POR and BOD requirements are fulfilled to the maximum extent.

1.4 Sustainable Design Requirements

For the design, construction and renovation of EPA facilities, the Project A/E must meet the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements.

1.5 Energy and Water Efficiency – Life Cycle Cost Analyses and Simulation Modeling

Energy and water efficiency requirements include the following. Where LCCAs or energy simulation modeling are required, see Sections 1.5.1, Life Cycle Cost Analyses, and 1.5.2, Energy Simulation Models, below for details.

- **Incorporation of Energy and Water Assessment Recommendations:** For renovations at an existing EPA facility, the EPA Project Manager and representative EPA staff must review the energy and water efficiency measures recommended in prior energy and water assessments and determine which measures to include in the POR. The Project A/E may be requested in the POR to conduct feasibility analyses and LCCAs to determine which measures to include in the design.
- **Equipment Analyses and Selection:** Federal agencies, including the EPA, are required to ensure that any capital energy-using equipment investment uses the most energy-efficient designs, systems, equipment and controls that are life cycle cost-effective (Energy Independence and Security Act of 2007 [EISA], Section 434). This requirement applies to projects in an existing EPA-occupied building that are not a major renovation, but that involve replacement of existing equipment/systems (e.g., boilers, chillers) or involve the renovation, rehabilitation, expansion or remodeling of existing space. For all projects, the EPA is required to use ENERGY STAR or FEMP-designated equipment where feasible (Energy Policy Act [EPAct] of 2005, Section 104).
- **Energy Performance for New Construction:** For new construction projects, the Project A/E must prepare energy simulation models and submit analyses showing the building(s) will exceed ASHRAE Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, to the energy performance level required by the *Guiding Principles for Sustainable Federal Buildings*, 10 CFR 433, and any other federal mandates. Consult 10 CFR 433 for details on required calculation methodologies (including energy simulation modeling per ASHRAE Standard 90.1 Appendix G: Performance Rating Method) for energy performance and life cycle cost-effectiveness. In addition, projects must comply with the IBC and IECC.
- **Energy Performance for Major Renovations:** For major renovations of existing facilities, the Project A/E must prepare energy simulation models and submit analyses showing the renovations will meet ASHRAE Standard 90.1 and the energy performance level required by the *Guiding Principles for Sustainable Federal Buildings,* any other federal mandates, the IBC, and the IECC. If achieving the *Guiding Principles for Sustainable Federal Buildings* energy performance requirement is not life cycle cost-effective, the Project A/E must prepare LCCAs and additional energy simulation modeling to evaluate the level of energy reduction that is life cycle cost-effective.
- **Renewable Energy:** The EPA Real Property Services Division and EPA Safety and Sustainability Division jointly shall determine and will include in the POR which renewable energy technologies are potentially

feasible for the project and warrant further analysis. For these selected technologies, the Project A/E must prepare LCCAs and implement the renewable energy technologies that are life cycle cost-effective.[1]

1.5.1 Life Cycle Cost Analyses

LCCAs must be completed and submitted during project design as indicated in Section 1.3, Design Process, above. To perform LCCAs, the Project A/E must use the NIST Building Life Cycle Cost (BLCC) Program, which incorporates the federal LCCA standards established in NIST Handbook 135, *Life Cycle Costing Manual for the Federal Energy Management Program*, and the energy price indices and discount factors from the most recent *Annual Supplement to NIST Handbook 135*. NIST Handbook 135 must be followed in evaluating the cost-effectiveness of all new construction or major building renovation projects, potential energy and water conservation projects, and renewable energy projects. As of the writing of this document, the NIST BLCC and supporting documents are available for download at https://www.energy.gov/eere/femp/building-life-cycle-cost-programs.

1.5.2 Energy Simulation Models

Hourly energy simulation models are essential to evaluating designs for new buildings and major renovations of existing buildings. All energy consumption and savings modeling performed shall meet the following general requirements:

- The modeler shall follow the performance-based energy budgeting methodology specified in 10 CFR 433.
- The energy simulation software package(s) must use calculation engines approved for code compliance modeling and must be approved in advance by the EPA Project Manager.
- The modeler shall submit a copy of the models in their native file format and an Energy Simulation Model Report (ESM Report) containing a summary of input parameters, a list of assumptions, tabular and graphical summaries of the model results, and an analysis of results. All raw data and model outputs shall be provided as a PDF appendix to the ESM Report or in other suitable file formats. Inputs to be submitted include, but are not limited to:
  - Local weather data.
  - Building usage profiles.
  - Building envelope characteristics with component information, coordinated with specifications.
  - Utility rates for all utilities that service the facility, whether locally based or distant, including transportation charges.
  - Equipment operating characteristics (e.g., temperature ranges, pressure drops, assumed or rated efficiencies, power consumption).

  Input parameters shall be organized (preferably in a table) based on each major occupancy (e.g., laboratories, office space) in the building(s) being modeled. Takeoffs, such as walls, roof, and window areas, shall also be tabulated in the ESM Report.
- Total energy consumption and savings shall be expressed in million British thermal units (MMBtus) and in thousand Btus per gross square foot (kBtu/GSF). Electricity, natural gas, high-temperature hot water, and steam inputs or purchases shall be converted to Btus using standard factors. (The conversion factors used shall be documented and submitted to the EPA in the ESM Report.)

---

1 As of the writing of this document, the U.S. Department of Energy (DOE) has not issued a final rule regarding the EISA Section 433 and Section 523 requirements for specified fossil fuel-generated energy reductions and solar hot water, respectively. Therefore, the EPA is implementing the renewable energy requirement as stated in the *Guiding Principles for Sustainable Federal Buildings*.

1.6 Design Based on Atmospheric and Laboratory Conditions

The Project A/E must evaluate project-specific atmospheric and laboratory conditions, such as, but not limited to, corrosivity, temperature, and noise, and design the project to properly account for these conditions. All equipment and materials shall be suitable for the environment in which they will be installed. Noise mitigation shall be provided for equipment, such as transformers and generators, in accordance with local codes (for offsite impacts) and with Occupational Safety and Health Administration (OSHA) requirements (for onsite impacts).

1.7 Commissioning

Commissioning is required for all EPA new construction and renovation projects, unless the EPA Project Manager and EPA Real Property Services Division Director agree that commissioning is not justified. The EPA will separately contract for an independent Commissioning Authority during the pre-design phase. The EPA's commissioning process is documented in the *EPA Building Commissioning Guidelines*. Systems to be considered for commissioning include, but are not limited to, the building envelope (e.g., walls, roofing, windows, doors), plumbing systems, HVAC system, BAS controls, electrical systems, fire protection and life safety systems, renewable energy systems, and security systems. The Project A/E and the Construction Contractor shall coordinate with the independent Commissioning Authority per the roles and responsibilities outlined in the *EPA Building Commissioning Guidelines*.

The fire protection and life safety systems component of commissioning shall comply with NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*. In addition, the integrated fire protection and life safety system testing procedures developed and conducted by the Construction Contractor shall meet NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing*.

1.8 Construction Process

The Project A/E shall incorporate the construction process requirements discussed in this section into the project specifications and contract documents.

1.8.1 Construction Management

To ensure that construction activities are conducted in accordance with applicable requirements, statements of work and specifications, the Construction Contractor shall provide the following plans for the EPA's review and approval:

- A Work Plan that includes roles and responsibilities and project schedule and milestones. As part of the Work Plan, the Construction Contractor will conduct weekly project management meetings to review project status and resolve issues.
- A Construction Quality Control (CQC) Plan that will implement the requirements of the quality control system. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the work to be started. As part of the CQC Plan, the Construction Contractor shall:
  - Establish a program for inspection of activities affecting quality that covers both onsite and offsite construction operations. At a minimum, inspections must be performed at the following times: prior to beginning any work on any definable feature of work; as soon as a representative portion of a feature of work has been accomplished; daily following the initial inspection of the accomplished work; and at completion of a feature of work.
  - Establish a test program to ensure that all required materials testing procedures are properly identified, planned, documented, and performed under controlled and suitable environmental conditions.
  - Provide the control, verification and acceptance testing procedures for each specific test, including the test name, specification paragraph requiring a test, feature of work to be tested and person responsible for each test.

The Project A/E shall provide quality assurance for the verification of the adequacy and effectiveness of the Construction Contractor's quality control testing.

- A Construction Stormwater Pollution Prevention Plan (SWP3) and/or Erosion and Sediment Control (ESC) Plan (see Section 3.2.6, Stormwater Runoff, within these A&E Guidelines). As part of the SWP3 and/or ESC Plan, the Project A/E shall conduct regular inspections of the erosion and sediment controls (during construction) and stormwater management system (post-construction).
- An Emergency Response Plan, to ensure a plan in place to deal with emergencies and unforeseen events.
- As applicable, a Spill Prevention, Control and Countermeasure Plan.

The Construction Contractor shall provide submittals during construction that include, but are not limited to:

- Daily or weekly construction reports, including photos and videos when requested, as determined by the EPA Project Manager.
- Minutes from regularly scheduled construction progress meetings.
- Inspection and testing report forms.
- Interim progress reports.
- Hot work and confined space entry permits.

The Construction Contractor shall permit the EPA's selected independent Commissioning Authority to conduct scheduled or unscheduled monitoring and inspections during construction activities. Any identified issues that cannot be resolved shall be brought to the attention of the EPA Project Manager for evaluation and resolution.

1.8.2 Construction Indoor Air Quality Management

To protect and manage indoor air quality during construction and prior to occupancy, the Construction Contractor shall:

- Submit a Construction Indoor Air Quality Management Plan for the EPA's review and approval detailing how the below requirements will be implemented.
- Follow the recommendations in the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) *IAQ Guidelines for Occupied Buildings under Construction* for construction in both occupied and unoccupied space.
- Avoid using permanent HVAC equipment serving construction areas during facility construction work. If the permanent HVAC system must be used during the construction process, the following conditions must be met:
  - A complete air filtration system, in compliance with the SMACNA standard mentioned above, is installed and properly maintained.
  - All filter media is inspected on a weekly basis and replaced if excessive loading or filter damage is noted.
  - No permanent diffusers are used.
  - No plenum-type return air system(s) are employed.
  - The HVAC duct system is adequately sealed to prevent the spread of airborne particulate and other contaminants.
- Prohibit all construction personnel from smoking within the building(s) under construction or renovation and within 25 feet of all building entrances, operable windows and building ventilation intakes.

- After construction is completed and prior to flush-out or indoor air quality testing:
  - Use high-efficiency particulate air (HEPA) vacuums to clean any ductwork that was (1) used to move supply or return air during construction; or (2) within the project boundaries and reused/remained in place. Confirm ductwork cleanliness using the verification methods in the National Air Duct Cleaners Association *Assessment, Cleaning, and Restoration of HVAC Systems* standard.
  - Remove temporary filters and duct coverings used during construction and install new air filtration media with a minimum efficiency reporting value (MERV) of 13 or better.
  - Conduct HVAC system testing, adjusting and balancing (TAB) after any HVAC system alteration to ensure the system is operating according to design specifications.
- After all interior finish installations, punch-list items, cleaning and HVAC TAB are complete, follow the flush-out or air testing requirements of the LEED for Building Design and Construction: New Construction v4 "Indoor Air Quality Assessment" credit (regardless of whether the project is pursuing LEED certification).
- If the project implemented a flush-out, inspect the HVAC filters after the flush-out and install new MERV 13 or better air filters if necessary.

1.8.3 Construction Waste Management

The Construction Contractor shall recycle as much material as possible throughout all project phases. To accomplish this, the Construction Contractor shall:

- Submit a Construction Waste Management Plan for the EPA's review and approval detailing how the waste stream will be separated and managed.
- Provide onsite instruction on the appropriate separation, handling, salvage, reuse, recycling and return methods to be used by all parties at the appropriate stages of the project.
- Each month, provide delivery receipts for materials sent to the permitted reuse, recycling, processing or landfill/incineration facilities, with all of the following information:
  - Name of the firm accepting the materials.
  - Type of facility accepting the materials (e.g., retail facility, recycler, processor, landfill, materials recovery facility).
  - Location of the facility.
  - Type of materials being sent to the facility.
  - Net weights of each type of material being sent to the facility.
  - Date of delivery to the facility.
  - Value of the materials or tipping fee paid.
- Upon completion of project, provide a final accounting of disposition of all materials.

The Construction Waste Management Plan shall ensure the following EPA recycling targets are met or exceeded:

- For projects less than 20,000 GSF, a minimum of 50 percent of construction waste by weight shall be salvaged, reused or recycled.
- For projects greater than or equal to 20,000 GSF, a minimum of 75 percent of construction waste by weight shall be salvaged, reused or recycled.

1.8.4 Project Closeout

As part of project closeout, the Project A/E, Construction Contractor, Commissioning Authority and other team members shall conduct activities and provide submittals that include, but are not limited to, the items described below.

Red Zone Meeting

The Red Zone meeting will be held approximately 60 days prior to the beneficial occupancy date. The EPA Project Manager, Project A/E, Construction Contractor, Commissioning Authority and other necessary team members will meet to discuss the closeout process, to schedule activities, and to assign responsibilities for these activities to complete a timely physical and financial project closeout. During the Red Zone meeting, the team will discuss actions and documents that affect construction warranty management and turnover of the facility. These include, but are not limited to, pre-final and final inspections, performance verification test dates, fire alarm and fire protection system tests, pre-commissioning and commissioning dates, warranty plan and inspection, final cleaning, as-built and record documents, O&M manuals, training, and occupancy.

Pre-final Inspection and Punch List

Prior to acceptance of the work, the Construction Contractor shall participate with the EPA Project Manager and Project A/E in a pre-final inspection and develop a punch list of items that do not conform to the approved plans and specifications. The Construction Contractor shall document when and how punch list items are addressed and provide the documentation to the EPA Project Manager and Project A/E for review.

Testing, Adjusting and Balancing

The Construction Contractor shall retain an independent TAB contractor to test, adjust and balance the air-moving equipment, air distribution system, water system, gas system and compressed air piping systems, as applicable. The independent TAB contractor shall be an organization that is a member of the Associated Air Balance Council (AABC) and/or the National Environmental Balancing Bureau (NEBB). A TAB report shall be provided to the EPA Project Manager.

After TAB has been completed and the TAB report has been approved by the EPA Safety and Sustainability Division, unless otherwise directed by the EPA Project Manager, the Construction Contractor shall have each laboratory fume hood tested and certified by a third-party, qualified fume hood testing agent in accordance with the *EPA Performance Requirements for Laboratory Fume Hoods* “As Installed” requirements. An EPA Safety and Sustainability Division representative must be present to witness the tests.

Commissioning

The Project A/E and Construction Contractor (including the TAB contractor and BAS contractor) shall coordinate and cooperate with the EPA’s independent Commissioning Authority throughout the design and construction process in accordance with the roles and responsibilities outlined in the *EPA Building Commissioning Guidelines*. As stated in these *Guidelines*, one of the many responsibilities of the Construction Contractor is to prepare testing procedures, provide all tools and instruments required for the commissioning process, complete pre-functional and functional testing, and correct any deficiencies. The Commissioning Authority will provide a final commissioning report.

Final Inspection

After punch list items, TAB and commissioning are complete, the EPA Project Manager and Project A/E shall conduct a final inspection to verify conformance with the contract documents for final acceptance.

Warranty Plan and Inspection

The Construction Contractor’s Warranty Plan shall provide the information necessary to contact the Construction Contractor during the warranty period and shall include the Construction Contractor’s procedures for correcting warranty issues. The EPA Project Manager and EPA Facility Manager will review the plan prior to approval and ensure that a warranty inspection is completed before project closeout.

Final Cleaning

After substantial completion, the Construction Contractor shall conduct a final cleaning.

As-Built and Record Documents

The Construction Contractor shall provide redline as-built drawings and specifications. The Project A/E shall prepare final record drawings to include the Construction Contractor's noted as-built conditions.

Operations and Maintenance Manuals

The Construction Contractor shall prepare O&M manuals and provide training to the building O&M personnel on how to operate the building. The O&M manuals must include, at a minimum, as-built/record drawings, environmental regulatory operating licenses/registrations/permits for each piece of equipment, equipment data, model numbers for the equipment, parts lists, equipment options, operating manuals for each piece of equipment, TAB reports and certifications, maintenance schedules, and warranty schedules. The manuals will be reviewed and certified as complete by the EPA Project Manager before submission to the EPA Facility Manager.

Extra Materials, Spare Parts and Maintenance Products

The Construction Contractor shall provide, deliver to the project site, and place in a location directed by the EPA extra materials, spare parts, and maintenance products in quantities stipulated in the specifications.

GreenCheck

To demonstrate that the project has been designed and constructed to meet the *Guiding Principles for Sustainable Federal Buildings* and any other federal sustainable building requirements, the EPA Project Manager, in coordination with the EPA Safety and Sustainability Division and the Project A/E, will complete a substantial completion phase GreenCheck form.

This page intentionally left blank.

2. Security

2.1 Process for Determining Security Requirements

Physical security aspects in the planning, design, and construction of EPA facilities is a collaborative effort among the EPA Office of Administration's Security Management Division, Real Property Services Division, and Safety and Sustainability Division. SMEs from each division are available to provide counsel and direction to ensure that EPA facilities are in compliance with established physical security policies and standards.

Each EPA facility is unique, and inherent differences such as physical design, physical access points, geographic location, threat environment and age of the structure(s)—among others—will have a direct impact upon security countermeasures. Prior to designing or renovating an EPA facility, the EPA Security Management Division has the primary responsibility for conducting a physical security risk assessment to identify the facility's vulnerabilities and customize the countermeasures needed to meet the facility's required level of protection. If the U.S. Department of Homeland Security's Federal Protective Service has a presence at an EPA facility, the EPA Security Management Division incorporates the Federal Protective Service's input into the physical security risk assessment.

As part of the physical security risk assessment, the EPA will follow the U.S. Department of Homeland Security's Interagency Security Committee's (ISC's) *The Risk Management Process for Federal Facilities* criteria to assign a facility security level (FSL) to the facility. The FSL (Level I, II, III, IV or V) is determined based on several factors, including mission criticality, symbolism, facility population, facility size and threat to tenant agencies. Facilities determined to have lower levels of risk will require lower levels of protection and likely fewer countermeasures. Conversely, facilities with higher levels of risk will require higher levels of protection and the implementation of greater countermeasures. Using the facility's FSL, baseline level of protection and unique risk factors, the EPA will identify in the physical security risk assessment the recommended countermeasures, including, but not limited to, physical access control systems (PACS), video surveillance systems (VSS), intrusion detection systems (IDS) and duress alarms, as well as physical security measures.

The Project A/E shall implement the countermeasures recommended in the physical security risk assessment to protect personnel and mission-critical equipment and data. In addition, the Project A/E shall refer to the ISC's policies, standards, best practices, guidance documents, and white papers; NIST standards and guidance; and installation guidelines to be provided by the EPA to inform the design and implementation of physical security elements of the project. EPA facilities must conform to the ISC policies and standards and the NIST standards and guidance; the EPA may stipulate agency-specific means and methods for achieving these requirements.

Both the ISC and NIST have established and organized standards in seven security areas:

- **Site Security:** Including, but not limited to, the site perimeter, site access, exterior areas and assets, and parking.
- **Structure Security:** Including, but not limited to, structural hardening, façade, windows and building system.
- **Facility Entrance Security:** Employee and visitor pedestrian entrances and exits, loading docks, and other openings in the building envelope.
- **Interior Security:** Space planning and security of specific interior spaces.
- **Security Systems:** PACS, VSS and IDS.
- **Security Operations and Administration Criteria:** Planning, guard force operations, management and decision-making, and mail handling and receiving.
- **Cyber Security Criteria:** Protections in place to reduce the loss of availability, integrity, and/or confidence of a security system and identify when unauthorized access has occurred.

2.2 Physical Access Control

2.2.1 FSL-I and FSL-II

For facilities determined to have an FSL-I or FSL-II rating, building perimeter ingress/egress, including access points to secured storage or critical areas as determined by the physical security risk assessment, shall be secured with non-removable hinges, automatic door closers, and high-security mechanical or electronic locks. Procedures for limiting access shall also be established at these levels. PACS readers are not required but may be installed in selected locations as determined by the physical security risk assessment.

2.2.2 FSL-III and Higher

The EPA is moving to the utilization of PACS readers that have multi-factor authentication capabilities. Which authentication mechanisms are or are not "turned-on" on each individual reader will depend on where the reader is located and under what environment the reader operates. Table 2-1 below outlines the security categories and number of authentication mechanisms recommended in NIST Special Publication 800-116, Revision 1, *A Recommendation for the Use of PIV Credential in PACS*. For each security category, Table 2-1 lists example EPA spaces that require this level of security and authentication. The designation of "Controlled," "Limited" and "Exclusion" areas shall be applied to the protected areas within every EPA facility.

For new installations or for retrofits where PACS already exists, multi-factor authentication PACS readers must be placed at all building perimeter entry points, excluding roll-up doors (to be monitored by IDS only) and exterior-facing general storage with no continued access to the facility. Exterior-facing hazardous materials storage must be monitored by PACS readers, VSS or IDS (one system minimum per ISC), as determined by the physical security risk assessment and the physical attributes of the facility's security posture. For multi-tenant facilities, the building perimeter is defined as the perimeter of EPA-leased or contractually/operationally responsible space. For single-tenant facilities, stairwells must have PACS readers on the unsecured side of ground-level and below-ground entry points only. For multi-tenant facilities where other tenants or the public have access to stairwells, the EPA must have PACS readers on the unsecured side of stairwell doors to each floor occupied by the EPA. For elevators (passenger or freight), the same methodology applies as identified for stairwells. PACS readers for elevators are to be installed on the wall outside the elevator, not internal to the elevator, except where pre-existing. The permission level of the person providing authentication at the elevator PACS reader will determine which floors the elevator will access. Anyone can call an elevator to any floor, and the elevator must access emergency egress levels, regardless of permission. These requirements exceed the ISC requirement of guarded versus unguarded entry points to ensure a minimum, consistent level of security at each facility in the event a guard force is not available or is removed as a presence at the facility.

In addition to the perimeter locations discussed above, PACS readers must be installed for rooms that store sensitive materials, such as personally identifiable information (PII), protected health information (PHI), classified materials, security systems or information regarding unique and critical assets. Normal business document storage rooms are not required to have PACS readers but must still be secured.

Table 2-1: Categorization of EPA Spaces by Security Category

Security Category	Number of Authentication Mechanisms	Example EPA Spaces
Controlled	1	Perimeter building entry points, access to program areas, hazardous materials supplies, facility services
Limited	2	Mechanical rooms, electrical rooms, telecommunications rooms, data centers, specialized laboratory spaces, special program area storage, areas storing sensitive documents or mission critical equipment
Exclusion	3	Most sensitive areas such as those containing trade secrets, special laboratory storage containing deadly agents, secure access facilities

2.3 Video Surveillance Systems

The design and necessary capabilities of the VSS will depend on several factors, including the security level of the facility, the type of facility, the environment in and around the facility, as well as the EPA's needs. Facilities with lower designated security levels will likely need a VSS that provides coverage of entrances, exits and pedestrian areas.

As the FSL increases, then so too will the requirements for the VSS. For higher level risk facilities, systems will need to be designed to capture views of both personnel and vehicles entering or leaving the facility, as well as monitor entry and exits from critical and/or sensitive areas such as interior lobbies, parking garages and loading dock areas. VSS standards for each FSL are listed below:

- **FSL-IV:** Provide coverage of screening checkpoints, exits, loading docks, lobbies, facility perimeter, parking areas, sensitive interior areas, pedestrian and vehicle entrances, and other potential access points.
- **FSL-III:** Provide coverage of screening checkpoints, exits, loading docks and lobbies.
- **FSL-II:** Provide coverage of personnel entrances and exits.
- **FSL-I:** No coverage is required.

VSS shall be mounted as high as possible, but not to exceed 9 feet above the finished floor, in locations that afford clear lines of sight to PACS-controlled entry points into the EPA space. The Project A/E shall not specify 180- or 360-degree cameras or pan-tilt-zoom cameras. Specify multiple fixed cameras to achieve coverage. Recordings shall be collected at 1080p (full HD) resolution, 15 frames per second, 24 hours per day, seven days per week and 365 days per year. Recordings shall be transmitted to a network video recorder or storage array with redundant drives and be stored for 30 days.

2.4 Intrusion Detection Systems

The IDS shall provide protection based on the site-specific FSL (see Table 2-2). The entire system shall be actively monitored at the facility's monitoring center (see Table 2-2) and locally recorded to monitor as evidentiary data if necessary. Monitoring centers must immediately notify the Federal Protective Service, local law enforcement or the onsite security guard force in the event of an intrusion.

Table 2-2: IDS Standards by FSL

FSL	IDS Standard	
IV	IDS Coverage	Provide IDS on perimeter entry and exit doors (Underwriters Laboratories [UL] 634 Level 2 high security sensors to be used for Level IV and higher), and all windows within 16 feet of the ground or other access point.
	IDS Monitoring	Monitor at an onsite central station during operating hours, and offsite after hours, with response by law enforcement or security responders.
III	IDS Coverage	Provide IDS on perimeter entry and exit doors and all ground-floor windows.
	IDS Monitoring	If IDS is in use, monitor at a central station with notification to law enforcement or security responders.
II	IDS Coverage	Provide IDS on perimeter entry and exit doors and operable ground-floor windows.
	IDS Monitoring	If IDS is in use, monitor at a central station with notification to a building manager or designated tenant point of contact.
I	IDS Monitoring	No special measures required. Install local annunciation if IDS is in use.

Roof access doors or hatches shall be secured with heavy-duty hardware and equipped with an alarm.

For FSL-III and higher facilities, additional critical areas where IDS shall be placed include access points to data centers, regional file centers, rooms where sensitive records (e.g., PII, PHI, classified materials, or information regarding unique and critical assets) are stored, and laboratories or other locations where hazardous materials might be used or stored.

2.5 Duress Alarms (Assistance Stations)

A duress alarm, sometimes referred to as a panic alarm, shall be installed at key public locations and other areas within EPA offices determined to have potential high threats and risks. For FSL-III and higher facilities, duress alarms shall be two-button, hard-wired, and hidden under desk or counter locations of the primary guard station, reception, and facility manager or most senior administrator. For all facilities, the physical security risk assessment will determine if additional duress alarm locations are needed and identify the required responder(s) for the duress alarms, consistent with ISC standards and the FSL.

Visible alarm stations and/or call boxes shall be placed in critical areas such as parking garages, walkways between buildings on a larger campus or in laboratory settings in the event of an emergency.

2.6 Supplemental Countermeasures

Beyond the installation of countermeasures interior to the building and exterior to the perimeter, consideration shall be given for utilizing supplemental countermeasures as further means to harden a facility and to protect employees. Listed below are a sampling of supplemental countermeasures for consideration when designing the facility:

- **Video Intercom System:** When determined to be advantageous by the physical security risk assessment, a video intercom may be located outside restricted access areas. These devices enable visitor management before entry is granted. The video intercom is not a substitute for a VSS. If recorded visitor management is required, a full-featured VSS must be used.
- **Exterior Lighting:** Install exterior lighting at entrances, exits, parking lots, garages and walkways from parking areas to entrances. Include infrared lighting in key locations to aid the VSS.
- **Fencing and Barriers:** Where there is a need limit pedestrian access, install fencing, landscaping or other barriers to channel pedestrians to authorized areas or entrances. For existing fences, consider raising the height of the fence.
- **Locks:** Utilize hardened mechanisms such as cipher locks to control access into restricted areas. Locks shall meet American National Standards Institute (ANSI)/Building Hardware Manufacturers Association (BHMA) Standard A156.30, *High Security Cylinders Product*, and ANSI/BHMA Standard A156.5, *Cylinders and Input Devices for Locks*.
- **Receptacle and Container Placement:** Position receptacles and containers (e.g., trash containers, mailboxes, vending machines) away from buildings, or implement blast containment measures to mitigate an explosion.
- **Vehicle Barriers:** Provide vehicle barriers to protect pedestrian and vehicle access points and critical areas/utilities from vehicle intrusions.

3. Planning and Siting

3.1 Siting Requirements

It is necessary to assess, analyze and address all site-related issues outlined below and to comply with the siting requirements of the *Guiding Principles for Sustainable Federal Buildings*; other federal, state, and local mandates; and the GSA Public Buildings Service (PBS)-P100, *Facilities Standards for the Public Buildings Service*.

3.1.1 Land Area

When planning and siting EPA facilities, the land and adjacent area will be considered during site selection. In general, the EPA encourages building on previously developed land, rather than on undeveloped property.

If brownfield sites are considered, the Project A/E must identify and select remedial actions and receive EPA approval prior to remediation. (Note: Remediation may occur before and/or during construction, as appropriate. For example, areas of contaminated soil are often removed during foundation investigations or installation.)

3.1.2 Floodplains

When siting the facility, the Project A/E shall locate any 100-year and 500-year floodplains in the area and delineate the floodplain boundaries on all surveys and site plans. Per Executive Order 11988, *Floodplain Management*; associated implementing instructions; and the *Guiding Principles for Sustainable Federal Buildings*, direct and indirect floodplain development shall be avoided whenever there is a feasible alternative. If siting in a floodplain is the only feasible alternative, the EPA shall issue the federally required notice of proposed actions and provide the required opportunity for public review. In addition, the Project A/E shall design the project to minimize potential harm, meet the standards of the National Flood Insurance Program, elevate structures above the 100-year flood level, and apply floodproofing measures.

Records storage facilities are subject to more stringent floodplain requirements per the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

3.1.3 "Smart Growth" Considerations

Smart growth principles shall be considered and encouraged for the sustainable siting of facilities, where practicable. In accordance with 40 U.S.C. 901-903, 40 U.S.C. 3312 and Executive Order 12072, local zoning laws and smart growth guidelines must be considered and incorporated into EPA facility siting and design. A fundamental component of community sustainability and effective local economic development includes coordination with other long-range plans for the area. The Project A/E shall engage relevant planning officials at the metropolitan, county or municipal level early in the site selection process to discuss the proposed development and understand local planning goals.

3.1.4 Zoning and Other Land Use Controls

In accordance with 40 U.S.C. 3312, the EPA and Project A/E shall consider and apply state and local zoning and land development requirements, wherever possible. A brief overview of state and local zoning and land development codes and their impacts on site development shall be included in planning and design documents. Any proposed deviations from such codes and laws are to be documented and fully justified.

Applicable zoning guidelines of university campuses, research parks or military bases will also be considered and followed (e.g., where an EPA facility is part of a greater planned campus). When zoning codes conflict, the most stringent standard must govern.

Laboratory facilities will be located in areas where local zoning allows; however, facilities must be at least 0.25 miles away from existing residential developments and must be located in such a way that prevailing winds will not direct fumes exhausting from EPA stacks toward existing residential developments. The potential transmission of noise above background levels is also a key consideration when siting new laboratories or undertaking major renovations of laboratories that would significantly increase existing noise levels.

Local regulations must be followed with respect to systems that have a direct impact on offsite terrain or utility systems (e.g., stormwater runoff, erosion control, sanitary sewers and storm drains, water supply, gas, electrical power and communications, emergency vehicle access, roads, bridges).

With respect to parking spaces, the design requirements given in the project's POR take precedence over zoning ordinances. The Project A/E shall consider strategies to address and resolve any zoning concerns or conflicts.

Coastal Zones

Per Section 307 of the Coastal Zone Management Act of 1972 and 15 CFR 930, the Project A/E must collaborate with the EPA and prepare, for projects that meet the following criteria, a consistency determination demonstrating how the project is consistent with the enforceable policies of the state's federally approved coastal management program:

- The project is located in a state that has joined the National Coastal Zone Management Program.
- The project, regardless of whether it is within or outside a coastal zone, will have reasonably foreseeable effects on any coastal use (land or water) or natural resource of the coastal zone.

Refer to the National Oceanic and Atmospheric Administration's Office for Coastal Management website for additional guidance.

3.1.5 Historic Preservation

When selecting a new location for an EPA facility, the EPA encourages the use, preservation and rehabilitation of historic buildings. If the project will involve preservation and rehabilitation of an existing historic building, the Project A/E must use a qualified preservation design professional that meets *The Secretary of the Interior's Historic Preservation Professional Qualification Standards*.

Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to consider the effects of their undertakings on historic properties—properties that are either listed or eligible for listing in the National Register of Historic Places. Per 36 CFR 800, an undertaking is defined as "a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a Federal agency, including those carried out by or on behalf of a Federal agency; those carried out with Federal financial assistance; and those requiring a Federal permit, license or approval." Section 106 is a requirement for the project proponent, not necessarily the land owner.

When selecting a site, the EPA will consult with the relevant State Historic Preservation Office, Tribal Historic Preservation Office, Advisory Council on Historic Preservation and other parties, such as local preservation organizations or neighborhood groups to determine whether the proposed properties are historic and, if so, how the proposed undertaking will affect the historic properties.

For projects that also require a National Environmental Policy Act (NEPA) analysis, the Section 106 processes can be combined with the NEPA effort. For more information, consult the Council on Environmental Quality's and the Advisory Council on Historic Preservation's *NEPA and NHPA: A Handbook for Integrating NEPA and Section 106*. Refer to Section 3.3, NEPA Screening and Assessment, and Section 5.1, Historic Preservation, within these A&E Guidelines for additional information.

3.1.6 Utilities

The location, availability, and capacity of existing (and future) utilities and services must be taken into account when selecting and planning the project site. The siting of facilities near existing communities is strongly encouraged to reduce natural and financial resources required for construction and maintenance of utilities infrastructure.

Locations and designs for service lines must comply with local and utility service requirements. Utilities include, but are not limited to, potable water, sanitary sewer, storm sewer, electrical power and communications.

3.2 Pre-Development Investigations

Pre-development investigations are required for all projects and will include some or all of the following: site resource inventory and analysis, land surveys, geotechnical/subsurface investigations, environmental investigations, and stormwater hydrology investigations.

The purpose of pre-development investigations is to provide the EPA with sufficient and pertinent data to allow a complete evaluation of the physical conditions of the given project site. The Project A/E will review the pre-development investigations to determine key design parameters, constraints and considerations for the project.

3.2.1 Site Resource Inventory and Analysis

The site resource inventory and analysis shall include, but must not be limited to, the following:

- The site overview, including location, parcel delineation and acreage, existing zoning, adjoining land uses, and view corridors.
- Physical site characteristic analyses, including topographic and elevation analysis, slope analysis, existing vegetation identification, geological and soils analysis, hydrology and drainage analysis, site analysis, wetlands analysis, buildable areas analysis indicating the acres of land that are suitable for construction, solar and shadow studies, and analysis of prevailing winds.
- Utilities overview and analysis, including stormwater drainage, potable water, sanitary sewer, electrical power and communications, and mechanical systems.

In addition, the Project A/E must consider local planning and zoning criteria for the subject property. This consideration will include investigation of all potential site development regulations, such as density limitations, building setbacks/standoff distances, building height, building coverage, buffer requirements, and other development guidelines set forth in any applicable campus, site, or facility master plan or elsewhere in these A&E Guidelines.

It is recommended that an onsite investigation and review be conducted, which includes representatives of the EPA, the Project A/E and the site owner, to verify land features indicated on the survey. Photographs shall be taken at various locations to provide a visual record to aid in the development of the site analysis drawings.

Some pre-development investigation activities will be performed before or after the site resource inventory and analysis is completed. Requirements and guidelines, as they pertain to specific pre-development investigations, are discussed below.

3.2.2 Land Surveys

Land surveys must be performed for all applicable construction projects, typically for projects involving site work. All land surveys must be performed by, or under the supervision of, a Professional Engineer and/or land surveyor registered in the state of performance.

At a minimum, the survey(s) must show legal property boundaries, easements, and legal restrictions, as well as all anthropogenic and natural physical characteristics, utility service locations (temporary and permanent), horizontal and vertical controls, benchmarks, roadways, and parking areas.

Land surveys shall conform to GSA PBS-P100 and the *Minimum Standard Detail Requirements for ALTA/ACSM Land Title Surveys*, as applicable. The degree of accuracy of construction, control, property and topographic surveys shall be consistent with each survey.

Engineering stake-outs must be prepared for all foundation footprints to verify that the footprint is entirely within the property legal description. Where requested, construction staking and as-built surveys for new EPA facilities shall comply with local standards and with practices approved by the EPA Project Manager.

Survey field notes shall be legibly recorded. Field notes, final plat-of-surveys, boundary surveys and recorded maps shall be submitted to the EPA Project Manager.

3.2.3 Geotechnical/Subsurface Investigation

For projects involving site work, geotechnical/subsurface investigations are required. Geotechnical/subsurface investigations will take place during site selection, building design and/or construction.

Preliminary subsurface exploration will be performed by a geotechnical Professional Engineer licensed in the state where the work is being performed. In the case that the Professional Engineer is a licensed civil engineer, geotechnical expertise must be demonstrated through experience, as approved by the EPA Project Manager. The geotechnical engineer will supervise all required testing, review and analyze all data and samples, and submit a report.

All tests will be performed by independent testing laboratories. Subsurface investigations and submittal requirements shall conform to the guidelines outlined in GSA PBS-P100, Appendix A, Section A.5, as applicable. The geotechnical engineer shall include in the report how best to address site-specific situations, such as soft soils, non-native fill materials, and unstable surfaces and subsurface features (e.g., landslide, subsidence, earthquake hazard).

Subsequent geotechnical/subsurface investigations must be performed under the direction of a licensed Professional Engineer. For permanent structures, subsurface conditions will be determined by means of exploratory soil borings or other methods that allow the engineer to adequately determine soil and groundwater conditions.

A profile of soil permeability, for use during design of the site stormwater management system, must be determined using ASTM D3385, *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer*, or ASTM D5093, *Standard Test Method for Field Measurement of Infiltration Rate Using Double-Ring Infiltrometer with Sealed-Inner Ring*. Data obtained from previous and preliminary subsurface investigations will be used, along with any additional investigations at the location that are deemed necessary. Groundwater levels must be recorded when initially encountered and after they have been allowed to stabilize. In earthquake-prone areas, appropriate geological investigations must be made to determine the contribution of the foundation (subsurface) to the dynamic earthquake loads imposed on the structure.

These investigations shall include, but must not be limited to, a recommendation of foundation type, determinations of allowable soil bearing capacity and assessment of the possible effects of seismic activity on the soil mass. A settlement analysis under different design loads shall be performed where differential settlement will cause structural, architectural or any other type of building damage. Possible mitigating measures (e.g., piers, piles, caissons, dampers) must be evaluated. (See the discussion under Geologic Hazard Investigation below.)

The Project A/E's results and engineering recommendations from subsurface investigations shall be submitted to and reviewed by the EPA Project Manager. Additional subsurface investigation requirements and documentation are discussed in the following sections.

Groundwater Investigation

A groundwater investigation must be performed for projects involving site work and for projects involving the selection of a dewatering control system. The investigation must examine the character of subsurface soils, groundwater conditions and groundwater quality. The source of seepage shall be determined, and the boundaries and seepage flow characteristics of geologic and soil formations at, and adjacent to, the site must be analyzed in accordance with the mathematical, graphic and electro-analogous methods discussed in the Unified Facilities Criteria (UFC) 3-220-05, *Dewatering and Groundwater Control*.

Geologic Hazard Investigation

During the planning and siting phase, a geologic hazard report must be prepared for all new building construction in regions of low, moderate and high seismicity, except for structures located in regions of low seismicity designed to the Life Safety Performance Level, as defined by the American Society of Civil Engineers (ASCE)/Structural Engineering Institute (SEI) 41, *Seismic Rehabilitation of Existing Buildings*.

In-depth geologic hazard investigations are not generally required for minor facilities for which earthquake damage would not pose significant risk to building occupants or the property. However, in general, new buildings shall have a thorough geologic hazard investigation performed.

If the geologic hazard investigation is not a stand-alone report, it shall be addressed in a section of the geotechnical/ subsurface investigation report, and it shall include recommendations for hazard mitigation.

Geologic hazards to be considered and avoided when siting the facility include, but are not limited to, active fault lines, areas with soils susceptible to liquefaction, and zones susceptible to slope failure or landsliding. Refer to GSA PBS-P100 Appendix A, Section A.5 for additional guidance on geologic hazard report requirements and applicability.

3.2.4 Environmental Investigations

Environmental investigations must be performed prior to activities on a project site. As part of the environmental investigations, available historical records shall be thoroughly reviewed to determine if contamination is present.

Under the purview of NEPA, a categorical exclusion, environmental assessment or environmental impact statement will be required. For additional information in determining applicability and project requirements for NEPA review, refer to Section 3.3, NEPA Screening and Assessment, within these A&E Guidelines.

In addition, projects involving acquisition, transfer or termination of EPA interests in a real property must comply with the Community Environmental Response Facilitation Act, the Federal Property and Administrative Services Act, and 40 CFR 373, *Reporting Hazardous Substance Activity When Selling or Transferring Federal Real Property*.

Compliance with these requirements is facilitated through an Environmental Due Diligence Process (EDDP), which will identify, document, manage and mitigate potential contamination associated with the EPA's interest in the property. For additional information in determining applicability of an EDDP review, refer to Section 3.4, Environmental Due Diligence Process Activities and Review, within these A&E Guidelines.

Results from the NEPA and EDDP environmental investigations shall be provided to the EPA Project Manager and the Project A/E to inform the project design.

3.2.5 Stormwater Hydrology Investigation

Stormwater hydrologic analysis must be performed in accordance with applicable local and state regulations, as well as the EPA *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. The stricter of EPA stormwater management requirements or the local or state code will prevail. Local regulations vary, with hydrologic analyses and investigations often required for sites, based on the size of the site and the estimated pre-/post-development discharges. The Project A/E must consider the impacts that the project will have on the site and local environment with respect to surface water quality, drainage and runoff (during both construction and longer-term operation of the project).

Where available, local precipitation data shall be used in lieu of regional data for site-specific hydrologic modeling. The following information must be assembled for use in the hydrologic modeling of the project:

- Geographic location.
- Precipitation frequency data.
- Drainage area.
- Soil and cover.
- Runoff distribution.
- Groundwater.
- Rainfall intensity-duration curves based on historic record.

For the rainfall intensity measure, the design storm events must be based on a study of precipitation frequency, runoff potential and runoff distribution relative to the physical characteristics of the watershed. At a minimum, the rainfall intensity measure must be the 95th percentile rainfall intensity based on at least the last 30 years of data, wherever available. (The 95th percentile rainfall intensity is the rainfall intensity that 95 percent of storms do not exceed.)

Where available, stream gauge data shall be used to estimate design flows in major channels. Where stream gauge data are inadequate or unavailable, rainfall information shall be taken from documented sources, such as the National Oceanic and Atmospheric Administration Atlas 14. Design storm precipitation values taken from documented sources or derived by published engineering methodology must be used to estimate design flood discharges.

The hydrologic analysis will also be a component of the site resource inventory and analysis. In addition, it will assist with the site development design, particularly for stormwater management design.

3.2.6 Stormwater Runoff

Per EISA Section 438, for construction or renovations that disturb more than 5,000 square feet of land, the predevelopment hydrology of the property must be maintained or restored to the maximum extent feasible, with respect to temperature, rate, volume and duration. In addition, local code requirements for stormwater detention and retention must be followed.

For guidance on stormwater management, refer to Section 4.1, Stormwater Management, within these A&E Guidelines, as well as the EPA Environmental Management Manual.

Stormwater Discharges From Construction Activities

Construction activities at EPA facilities that disturb one or more acres of land will be required to obtain a National Pollutant Discharge Elimination System (NPDES) construction general permit. The specific construction general permit and application requirements are defined by the NPDES permitting authority (state or federal). These requirements may vary slightly but generally include:

- Submittal of a Notice of Intent that includes general information and a certification that the activity will not impact endangered or threatened species. This certification is unique to the EPA's Notice of Intent and is not a requirement of most NPDES-delegated state Notices of Intent.
- Development and implementation of an SWP3, describing appropriate best management practices (BMPs) to minimize the discharge of pollutants in stormwater runoff from the site.
- Submittal of a Notice of Termination when final stabilization of the site has been achieved, as defined in the permit or when another operator has assumed control of the site.

The primary method to control stormwater discharges at a construction site is through the use of BMPs. Refer to EPA 833-R-060-04, *Developing Your Stormwater Management Plan—A Guide for Construction Sites*, for guidance on developing SWP3s and for examples of proven stormwater management BMPs. Refer to the EPA Environmental Management Manual for additional guidance on NPDES requirements with respect to stormwater discharges and construction operations.

Erosion and Sediment Control

ESC measures (often also referred to as construction stormwater BMPs) and post-construction stormwater management BMPs must be implemented in accordance with federal, state, and local standards and permits. The site shall be properly graded and planted to minimize erosion.

Depending on the permitting authority and project size, an ESC Plan may be required as part of the local construction permit and NPDES permit application, integrated with (or over and above) the stormwater management plan or SWP3. If required by the local state permitting authority, the ESC Plan shall be developed and integrated with the stormwater management plan and SWP3.

3.2.7 Wastewater Discharges

All wastewater discharges from EPA facilities, including discharges during construction activities, must comply with Clean Water Act requirements, as well as state and local restrictions. Depending on the activities at the EPA site, a wastewater discharge pre-authorization or permit may be required to discharge to the local publicly owned treatment works (POTW) water treatment facility.

For facilities that will have wastewater contaminants exceeding the requirements set forth by the EPA, state agencies and/or the local POTW, appropriate pretreatment equipment and systems must be installed prior to discharge to the sanitary sewer, and must meet EPA specifications and/or the requirements of the POTW and NPDES, as applicable.

Refer to the EPA Environmental Management Manual for additional information on wastewater management at EPA facilities.

3.2.8 Air Emissions

The Project A/E must assess all sources of air emissions and comply with federal, state and local requirements. The Project A/E must obtain any required air emissions construction permits and operating permits for the facility, prior to the start of construction.

Refer to the EPA Environmental Management Manual for additional guidance on air permitting requirements.

3.3 NEPA Screening and Assessment

NEPA (42 U.S.C. 4321 et seq.) and the EPA's implementing regulations (40 CFR 6) apply to all EPA facility construction, renovation and maintenance projects, regardless of size. The EPA Safety and Sustainability Division has also developed and published for internal use EPA 200-K-16-001, *National Environmental Policy Act Review Procedures for EPA Facilities*, which provides detailed instructions and tools for facilities to follow and utilize. For facility projects funded and executed through the EPA's Buildings and Facilities appropriation, the EPA Safety and Sustainability Division takes the lead in developing all NEPA supporting documentation for the project, working closely with their counterparts within the EPA Office of Administration that are overseeing the project. For facility projects directly funded and executed through the EPA's regional and program offices, it is incumbent upon the responsible official (as defined in the EPA's NEPA Review Procedures) to ensure compliance with the EPA's regulations and established procedures.

3.3.1 NEPA Review Process

The responsible official must follow the procedures outlined below:

- Determine the appropriate level of NEPA review for a proposed project.
- Define the significant issues to be analyzed through information gathering, scoping meetings and public participation.
- Evaluate project alternatives, including the proposed action and possible mitigation measures, to determine whether their environmental impacts are significant, not significant or none at all.
- Develop documentation to assist the public and decision-makers in evaluating the proposed action and alternatives.

The NEPA review process is not limited to strictly ecological effects, such as air and water quality. Effects to be considered also include aesthetic, cultural, historic, health and socio-economic impacts.

The EPA Project Manager is responsible for coordinating with the EPA Safety and Sustainability Division and ensuring that EPA facility projects comply with NEPA. If the EPA is working with the GSA to construct new space, the GSA is the lead agency and will prepare the documentation, and the EPA Project Manager will coordinate with the GSA as needed. The EPA Project Manager shall incorporate NEPA review for a proposed action at the earliest possible opportunity and promote continuous communication throughout the project until the NEPA process is complete. The final NEPA documentation shall be provided to the Project A/E to inform the project design.

3.3.2 Categorical Exclusions, Environmental Assessments and Environmental Impact Statements

NEPA compliance evaluations and reviews shall be conducted early in the planning and decision-making process for construction, renovation and maintenance projects. By doing so, the EPA will be able to identify viable alternatives, assess environmental impacts of these alternatives, provide a basis for informed selection of a preferred alternative and evaluate measures to mitigate adverse environmental effects of the selected alternative.

EPA projects are subject to the following levels of NEPA review and documentation:

- Categorical exclusion (CX).
- Environmental assessment (EA).
- Environmental impact statement (EIS).

A CX project is an action that is deemed to have no significant impacts. These actions do not individually or cumulatively have a substantial effect on the human environment. Actions include minor rehabilitation of existing facilities, functional replacement of equipment, and construction of new ancillary facilities adjacent to or appurtenant to existing facilities. These are generally routine actions that normally do not require an EA or an EIS. Actions eligible for a CX are defined in 40 CFR 6.204.

When a project does not meet the criteria for a CX, an EA must be prepared. The end result of an EA is a determination of a Finding of No Significant Impact (FONSI) or a Notice of Intent (NOI) to prepare an EIS. Note that, if preliminary review of an action reveals obvious potential significant environmental impacts, the review process should proceed directly to an EIS.

Because the need for an EIS indicates that significant environmental, social, cultural, and/or other impacts are anticipated or probable, the EPA discourages the selection of project sites that would require an EIS. If an EIS is required, the planning, development, distribution and public involvement will normally take 8 to 18 months to complete, hence, substantially delaying project completion.

For projects likely requiring an EA or an EIS, a scoping meeting should be employed to help prepare a clear and precise description of the proposed action and to identify reasonable alternatives.

Refer to EPA 200-K-16-001, *National Environmental Policy Act Review Procedures for EPA Facilitie*s, for detailed procedural guidance and information on applicability of the NEPA review processes.

3.4 Environmental Due Diligence Process Activities and Review

During a real property transaction—acquisition, disposition, transfer, lease assumption, lease termination, etc.—several actions may be required to ensure the agency manages its environmental risks properly. To systematically address everything, the agency developed its EDDP, which is based on ASTM E1527, *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Protocol*. The EDDP is described in detail in EPA 100-B-00-002, *Guidelines for Acquiring and Transferring EPA Real Property and Complying with the Community Environmental Response Facilitation Act (CERFA)*. The EDDP begins when a proposed action affects the EPA's interest in a property or facility. An initial review must be conducted to properly characterize the nature of the transaction and establish an agreed-upon course of action to properly implement the EDDP. Several EDDP review activities must be performed by various EPA organizations, including the EPA Office of Administration, EPA Safety and Sustainability Division, and applicable program and regional offices, to ensure that real property is transferred legally, on time and within budget. Every project is different, and no single solution will apply in every case. These activities can typically be performed either independently or concurrently and include:

- Equipment deactivation and decommissioning.
- Facility surveillance and monitoring.

- Removal and management of chemicals and hazardous substances.
- Permit/license transfer or termination.
- Management of personal property and surplus equipment.
- Building restoration and improvements.
- Coordinating and facilitating the EDDP.

EDDP review activities shall be applied when acquiring, transferring or terminating the EPA's interests in any real property, to include all leasing actions. When terminating the EPA's interest in real property, the results of the EDDP must be used to determine whether an environmental condition notification to purchasers or recipients is required under federal, state and local law. When transferring property to third parties, the results of the EDDP review shall be used to establish a baseline environmental record of the property as a defense against future claims.

It is important that the EPA concurrently evaluates financial, legal, NEPA, operational, occupancy and other considerations throughout the EDDP review.

3.5 Hazardous Materials Surveys

If hazardous materials are suspected to be present or are encountered during project programming and design, the Project A/E shall immediately inform the EPA Project Manager, and the EPA Project Manager shall determine the best course of action at that time. This may include conducting hazardous materials surveys prior to construction or demolition. If hazardous materials are identified during these surveys, the materials will be abated using a methodology approved by the EPA Project Manager. Hazardous materials include, but are not limited to, asbestos, lead-based paint, mold/mildew, polychlorinated biphenyls (PCBs) and mercury. Survey, abatement and material disposal activities must be conducted in accordance with appropriate regulations and industry standards.

This page intentionally left blank.

4. Site Development

Site development design and construction work must comply with all applicable federal, state, and local codes, regulations, and ordinances. In addition, site development design shall follow the guidelines prescribed in GSA PBS-P100. When codes conflict, the most stringent standard shall govern.

4.1 Stormwater Management

The stormwater management design must meet the *Guiding Principles for Sustainable Federal Buildings*, EISA Section 438 and the EPA *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. EISA Section 438 is relevant for projects that are constructing, reconstructing, or replacing structures or infrastructure; disturbing more than 5,000 square feet of ground area; and affecting the site hydrology (i.e., stormwater runoff volumes, rates, temperatures, or duration of flow). Example relevant projects include, but are not limited to, new building construction, building additions, new hardscape (e.g., parking lot, road, sidewalk), or new landscaping that regrades the site. The EISA Section 438 requirement does not apply to typical patching or resurfacing of existing paved areas or typical landscaping projects (e.g., updating plants in flower beds), because these projects do not increase the amount of impervious surface and do not affect the site hydrology. Per Part I, Section D of the EPA technical guidance, the design, to the maximum extent technically feasible, shall either:

- Manage rainfall on site and prevent the offsite discharge of precipitation from all rainfall events less than or equal to the 95th percentile rainfall event, or
- Replicate the pre-development hydrology based on a site-specific hydrologic analysis using continuous simulation modeling, published data, studies or other established tools. “Pre-development” is defined as the greenfield site condition prior to any human-induced land disturbance (e.g., meadow, forest).

4.2 Landscaping and Irrigation

4.2.1 General Requirements

The landscaping design process must coincide with the building design process to create a single design that integrates the site and building(s). All landscaping and site amenities for the project shall be in accordance with all applicable federal, state and local codes, including:

- *Guiding Principles for Sustainable Federal Buildings*.
- *Guidance for Federal Agencies on Sustainable Practices for Designed Landscapes* and its addendum, *Supporting the Health of Honey Bees and Other Pollinators*.

If the facility is part of an existing campus or among other buildings in a master-planned development, the landscape design, as well as building design, must be integrated and compatible with the style(s) of the campus. Landscaping and site amenities shall comply with any master plan design and construction requirements. The more stringent requirements shall be used if a conflict exists.

All site landscaping shall be designed by a state-registered landscape architect. The landscape architect must maintain his or her registration without break and show proof of professional liability insurance. The landscape architect shall also be proficient in water-efficient and climate-appropriate landscaping. The landscape architect shall preserve existing trees and undergrowth, where appropriate, for buffers and review buffer requirements of the local community.

All site landscaping shall be installed and/or modified by a professional landscaper or professional gardener. All landscaping (plants and grass) except for annuals, if used, shall be guaranteed for 16 months after acceptance by the EPA.

4.2.2 Irrigation

Irrigation is discouraged at EPA facilities, except for initial irrigation during the period in which new plantings are being established. Irrigation should be used sparingly and only if necessary. New designs that feature turf grass requiring regular irrigation are generally prohibited at EPA facilities. Where irrigation is required, systems must meet the requirements in the *Guiding Principles for Sustainable Federal Buildings*.

4.3 Hard Surfaces

The selection of hardscape surface materials shall be integrated with the building and landscaping design. Careful consideration should be applied during site planning and site development design to minimize the total footprint of impervious land required for roadways, sidewalks, driveways and parking areas. Ultimate material selection shall be based on permeability, durability under design traffic load, maintainability and cost-effectiveness. In addition, the following design considerations shall be taken into account:

- **Structural Performance:** The design, testing and construction for pavement shall comply with state and local highway department standards.
- **Porous Pavements:** The design, testing and construction for porous pavements shall comply with state and local highway department standards. Wherever practical, porous/pervious paving materials shall be used as substitutes for impervious surfaces. Pervious pavement may substitute for conventional pavement on parking areas, walkways and areas with light traffic. Pervious pavement is permitted in areas that have gently sloping or flat ground, have traffic from light-duty vehicles only, and will not receive snow and ice treatments. It is recommended that pervious pavements are installed in locations with soil infiltration rates greater than 0.5 inches per hour to provide appropriate water quality treatment and avoid the need to design the system with an underdrain. There should be a 4-foot minimum clearance from the bottom of the pavement system to bedrock or the water table. Porous materials are not recommended for areas that receive excessive sediment from adjacent runoff or areas that may be susceptible to chemical spills. Care should be taken during construction to prevent clogging of porous materials with debris.
- **Recycled Content:** The use of recycled content in hardscape surfaces is encouraged.
- **Heat Island Mitigation:** The use of materials that reduce the heat island effect is encouraged.

4.4 Traffic Control

Vehicle circulation for roadways, loading and unloading areas, parking areas, emergency vehicle access, pedestrian walkways and bicycle access shall be designed in accordance with applicable national, state and local code requirements and with any overall campus master plan in effect at the project site.

4.5 Electric Vehicle Infrastructure

The site design shall meet the *Guiding Principles for Sustainable Federal Buildings* requirements for electric vehicle charging infrastructure.

4.6 Site Utilities

The site planning investigations and surveys shall determine the availability and location of existing and available utilities such as water, wastewater, electricity, natural gas and telecommunications. The conditions of all existing and available site utilities shall be reviewed to determine their adequacy as it pertains to requirements imposed by a new or upgraded EPA facility. Refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional information about energy and water utility metering.

While the Project A/E is not authorized to make any commitments or negotiate contracts with the local utility service companies or municipal authorities, the Project A/E may be responsible for contacting the local utility service providers to collect information such as interest in providing service to the EPA facility, proposed rate structures and system capacities. Refer to GSA PBS-P100 for additional guidelines on utility coordination.

If any onsite or offsite utilities require adjustments to facilitate service for the project, the Project A/E shall furnish recommendations, including load requirements, service characteristics, cost analysis, schematic drawings and various alternatives, for each utility service.

When designing site utility systems, size and terminate utilities to accommodate possible future extensions. If expansion is planned, extend utilities to the edge of the site or to a point where a connection can be made without damage or disruption to the utility or adjacent structures. For utilities that can share corridors and piping, establish shared utility corridors to optimize land use and provide adequate utility separation. Ensure that aboveground utility elements such as transformers, generators and backflow prevention devices are located with convenient service access and are integrated with the building and site design.

Except for dense urban areas, where there is no feasible alternative, new buildings and structures should not be placed over existing sanitary sewer, water supply, stormwater drainage, electrical or natural gas lines.

Utilities systems shall be located at least 50 feet from loading docks, front entrances and parking areas. Access to utility areas shall be restricted to authorized personnel.

4.6.1 Water Supply

General

Water distribution systems shall be included within the utility master plan and shall be metered (refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional guidance). Water service meters shall be located inside the building to maintain security and supervision within the security perimeter.

The planning and routing of the piping system and access points must be determined early in the design process. Water lines shall not be located under foundations and other areas where access is severely limited. During route selection and initial planning for potable water distribution systems, the following conditions and requirements shall be considered:

- Projections concerning future population and development.
- Anticipated average daily flow for fully developed conditions.
- Anticipated peak flows for domestic, industrial, fire and special water usage.
- Hydraulic design criteria.
- Health and safety requirements.
- Physical constraints (e.g., utility corridors, topographic features).
- Energy conservation and environmental constraints.

Distribution system layouts shall be as simple and direct as possible. Where feasible, initial planning efforts shall optimize system layouts (e.g., system loop lines) in order to:

- Facilitate future system expansion.
- Minimize conflicts with other utilities.
- Reduce maintenance requirements.

Backflow preventers must be installed on all connections to public or private water supply systems, as specified in Section 7.7.1, Water Supply Systems, within these A&E Guidelines.

Potable Water

During design and construction planning, the potable water supply and local/municipal water authority shall be determined. Facilities that obtain drinking water from municipal sources have limited responsibilities for monitoring drinking water, except during initial construction or leasing. Drinking water in all newly constructed facilities must be tested to confirm compliance with the National Primary Drinking Water Regulations to ensure they do not exceed drinking water action levels. Refer to the EPA Environmental Management Manual for sampling requirements.

The design of potable water supply connections shall be coordinated with plumbing design, as detailed in Section 7.7, Plumbing and Piping, within these A&E Guidelines, and shall comply with codes and requirements of the local public water authority.

Nonpotable Water

The use of dual water systems (i.e., domestic and industrial or irrigation) or municipal graywater shall be considered but is subject to the approval of the EPA Project Manager. Where use of dual water systems is approved, the location and alignment of both systems must be clearly identified on the record drawings and by location markers at intervals specified by the EPA Project Manager.

4.6.2 Wells

Drinking Water

Where drinking water is derived from onsite wells and is provided to more than 25 individuals or 15 service connections for at least 60 days out of the year, facilities must comply with the requirements for "public drinking water systems" under the Safe Drinking Water Act. These systems are subject to periodic monitoring for physical, chemical, radiological and biological parameters as specified in 40 CFR 141 and 40 CFR 143. Facilities that obtain drinking water from onsite wells shall also be designed with sufficient pretreatment capabilities to ensure the safety and aesthetic quality of the water for general consumption. At a minimum, pretreatment systems for water obtained from onsite sources shall provide levels of performance that ensure fulfillment of the primary maximum contaminant levels in 40 CFR 141, the lead and copper action levels in 40 CFR 141.80, and the secondary maximum contaminant levels in 40 CFR 143.

Research Purposes

Where and when water must be provided for fish culture, onsite drilled wells shall be capable of producing a minimum of 20 gallons of water (of consistent quality) per minute, unless otherwise specified by the EPA Project Manager. The water must be of a suitable quality for rearing and maintaining fish cultures. It must not be contaminated with pesticides, heavy metals, sulfides, silica or chlorides. The anions should be those found in natural lakes or streams. Water quality parameters should be as follows:

- **Dissolved Oxygen:** > 6.0 milligrams per liter (mg/L).
- **pH:** 7.2–8.5.
- **Hardness:** 40–200 mg/L as calcium carbonate ($CaCO_3$).
- **Alkalinity:** Slightly less than hardness.
- **Iron:** < 1.0 mg/L.
- **Chlorides:** < 250 mg/L as chlorides and sulfates.
- **Sulfides:** < 2.0 micrograms per liter (µg/L) as undissociated H_2S.

The well and pump shall be protected from the elements. Two 500-gallon water tanks shall be installed as reservoirs for water prior to distribution.

4.6.3 Sanitary Sewer

The design of sanitary sewer connections shall be coordinated with the facility sanitary sewer design, as detailed in Section 7.7, Plumbing and Piping, within these A&E Guidelines and shall comply with codes and requirements of the local POTW. Refer to GSA PBS-P100 for additional guidance.

The following elements shall be considered during wastewater system design:

- Gray water reuse systems shall be implemented where cost-effective and permitted under local laws and regulations.
- Industrial wastewater and pollutants above the minimum concentrations specified by the EPA shall be excluded from sanitary wastewater collection systems.
- Pretreatment systems (e.g., acid neutralization) shall be installed where required and shall meet EPA specifications and/or requirements of the POTW and NPDES as applicable.

4.6.4 Natural Gas Supply

Gas distribution connections shall comply with federal, state, and local codes and requirements. Natural gas and other liquid fuel gas systems shall comply with NFPA 54/ANSI Z223.1, *National Fuel Gas Code*. Refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional information about required natural gas metering.

Natural gas piping shall not be run in trenches or other confined/unventilated spaces where leaking gas might collect and cause an explosion or in areas subject to fires. Natural gas piping shall not share the same trench or corridor with other utilities. The minimum horizontal clearance between a natural gas pipe and parallel utility pipe shall be 2 feet. Do not locate gas piping through other underground structures such as vaults, manholes or similar underground structures. When connecting to existing live gas mains, connections shall be made in accordance with American Society of Mechanical Engineers (ASME) B31.8, *Gas Transmission and Distribution Piping Systems*.

Natural gas service utility piping entering the building shall be protected from damage by vehicles, foundation settlement and vibration impacts. Where wall penetration above grade is not possible, the gas pipe shall be within a Schedule 80 black steel, corrosion-protected, sealed and vented, gas pipe sleeve that extends from 10 feet upstream of the building wall penetration exterior (or excavation shoring limits if greater) to 12 inches downstream of the building wall penetration.

4.6.5 Steam From District Energy Systems

The use of district energy systems to pipe steam to EPA facilities for thermal energy purposes shall be evaluated on a site-specific basis. For project sites that can be connected to a district energy system, the Project A/E shall coordinate with the energy source owner/operator to determine capacity and design requirements for the connections and system. If an EPA facility receives steam from a district energy system, this steam must be metered. Refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional information.

4.6.6 Electrical Power

Electrical power connections shall be coordinated with the electrical power design, as detailed in Chapter 8, Electrical Requirements, within these A&E Guidelines and shall comply with NFPA 70, *National Electrical Code*, as well as local codes and requirements. Refer to GSA PBS-P100 for additional guidance.

General requirements for electrical power include the following:

- A detailed load study, including connected loads and anticipated maximum demand loads, as well as the estimated size of the largest motor, shall be performed to determine the required capacity of the new electrical service. If the project is a renovation or an extension of an existing building, the history of the loads shall be carefully studied to ensure that the existing service entrance equipment has sufficient capacity to handle the loads of the addition or renovation and has spare capacity for future loads.

- The service entrance location for commercial or municipal electrical power shall be determined concurrently with the development of conceptual design space planning documents, and standards for equipment furnished by utility companies shall be incorporated into the concept design. Locations of transformers, vaults, meters and other utility items must be coordinated with the architectural design and must consider both equipment ventilation and equipment removal.
- The routing of electrical power and other site utilities, as well as the location of manholes and other access points, must be determined early in the design process, in coordination with the responsible site civil engineer.
- Cable selection shall be based on all aspects of cable operation and the installation environment, including corrosion, ambient heat, rodent attack, pulling tensions and seismic activity.
- On multi-building EPA campuses, electrical power shall be metered at the individual building level. Refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional information.

Overhead Services

Overhead services to buildings shall not be used, except in circumstances where underground services are not feasible. Where electrical service to the building is by overhead lines, proper dip poles, weatherheads and supports shall be provided. The main service switch, panelboard or switchboard shall be located immediately adjacent to the entrance of feeders into the building. Code-required clearances shall be maintained under all overhead lines. The openings necessary for bringing conductors into buildings shall be grouted or otherwise fire-stopped.

Underground Services

All underground secondary conductors (i.e., voltage less than 600 volts) shall be installed in direct buried conduits. Where secondary-service reliability is a prime consideration, secondary service ductbanks shall be concrete encased.

The minimum duct size of service entrance ducts shall be 4 inches. All other secondary conduits that might be necessary for power distribution to exterior lighting and other electrical loads shall be sized based on conduit fill as calculated in accordance with NFPA 70.

A minimum of 25 percent spare service entrance ducts (but not less than one spare duct) shall be provided. Spare ducts shall be plugged or capped to prevent contamination. Ensure conduits are watertight to 3 feet above the base flood elevation or the local design flood elevation, whichever is higher. The locations where manholes (if required) are to be included shall be investigated to ensure that they will drain properly.

Service Capacity

Incoming transformers must be provided, as required, and must be of sufficient capacity to accommodate the full design load, plus 30 percent additional capacity for future growth. To the greatest extent possible, public utility transformers shall be located outside of the actual building. If public utility transformers must be located within buildings because of site constraints, they shall be installed in standard transformer vaults conforming to NFPA 70 requirements. These vaults shall not be located adjacent to, or directly beneath, any exit from the building. In calculating the design load, a demand factor of 100 percent should be used for lighting and fixed mechanical equipment loads, and a demand factor of 75 percent should be used for all other loads.

Service Entrance Equipment

Service entrance equipment shall consist of a main switch or switches, a main circuit breaker or circuit breakers, or a main switchboard or panelboard. In determining whether the service entrance equipment should be of the fused or circuit breaker type, careful consideration shall be given to the short-circuit current available at various points in the proposed distribution system.

4.6.7 Telecommunications

The Project A/E shall coordinate with the local telecommunications company to determine the size, capacity and location of the incoming service, as well as the enclosure and pathway requirements, for a new system at the facility. Cable selection shall be based on all aspects of cable operation and the installation environment, including corrosion, ambient heat, rodent attack, pulling tensions and seismic activity.

4.7 Exterior Site Lighting

Exterior site lighting shall be designed to enhance safety and security onsite, provide adequate lighting for nighttime activities, and highlight any special site features. While exterior site lighting shall maintain safe light levels, site lighting shall also be designed to minimize light trespass onto surrounding properties, particularly if there are adjoining residential areas, in order to minimize and mitigate night sky pollution. Lighting from the perimeter into the site is preferred. The maintained level of illumination shall adhere to relevant codes, GSA PBS-P100 and other federal requirements. The same type of lighting that is used for parking lots shall be used for roadways and should be consistent in color and height. Energy-efficient, low-voltage or solar-powered lighting shall be used (i.e., ENERGY STAR or FEMP-designated products, as required by Section 104 of EPAct 2005). The lighting level standards recommended by the Illuminating Engineering Society's Subcommittee on Off-Roadway Facilities are the lowest acceptable lighting levels for an EPA parking facility.

Refer to Section 8.6, Lighting Systems, within these A&E Guidelines for additional requirements for site lighting.

This page intentionally left blank.

5. Architectural and Building Envelope Requirements

5.1 Historic Preservation

For projects affecting properties, structures or landscapes that are listed or eligible for listing on the National Register of Historic Places, the Project A/E must meet historic preservation requirements including, but not limited to, the following:

- National Historic Preservation Act.
- Archaeological Resources Protection Act.
- Native American Graves Protection and Repatriation Act.
- *The Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation* (as amended and annotated by the National Park Service [NPS]).
- *The Secretary of the Interior's Historic Preservation Professional Qualification Standards*.
- 36 CFR 68, *The Secretary of the Interior's Standards for the Treatment of Historic Properties*.
- 36 CFR 800, *Protection of Historic Properties*.
- Executive Order 11593, *Protection and Enhancement of the Cultural Environment*.
- Executive Order 13006, *Locating Federal Agencies in Historic Buildings in Historic Districts in Our Central Cities*.
- Executive Order 13287, *Preserve America*.
- Cultural Resource Management Guideline, NPS-28.
- Advisory Council on Historic Preservation's *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*.

5.1.1 Alterations in Historic Structures

Where a historic structure is to be altered, the Project A/E and the EPA Project Manager, in accordance with the Section 106 consultation process, shall engage with the EPA Federal Preservation Officer, State Historic Preservation Office, Tribal Historic Preservation Office, Regional Historic Preservation Office, preservation specialists, external review groups and other appropriate EPA specialists early in the design process to convey the proposed scope. Frequent coordination is necessary, and the stakeholders shall work together to mitigate any adverse effects identified. It is imperative to timely resolve conflicts between the application of preservation treatments and EPA project goals.

In general, alterations in historically significant spaces shall be designed contextually to blend with the original materials, finishes and detailing. When substantial repairs or alterations are undertaken in significant and highly visible locations, opportunities shall be sought to restore original features that have been removed or insensitively altered.

Alterations to historic preservation must comply with the requirements of the Architectural Barriers Act Accessibility Standard (ABAAS) Section F202.5, *Alterations to Qualified Historic Buildings and Facilities*. The team shall also refer to the Advisory Council on Historic Preservation's *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*.

5.2 Sustainability

With respect to architecture and the building envelope, the Project A/E's design must meet the *Guiding Principles for Sustainable Federal Buildings*, including requirements for energy efficiency, daylighting, environmentally preferable materials, occupant health and wellness (e.g., active design, exterior views), and climate resiliency. Product types included in the federal Green Procurement Compilation that are within the project scope shall meet the requirements, specifications, standards and ecolabels as stated in the federal Green Procurement Compilation: https://sftool.gov/greenprocurement.

5.3 Building Envelope

The building envelope shall conform to the International Building Code (IBC)/International Energy Conservation Code (IECC) for the associated climate zone. In some instances, the Project A/E may be required to conduct hygrothermal analysis in accordance with ASHRAE Standard 160 to demonstrate that the building envelope performance reduces the risk of moisture damage. Fenestration air leakage shall comply with the IBC/IECC.

- **Waterproofing and Flashing:** All drainage planes, cavities and through-wall penetrations shall maintain continuity of drainage with approved flashing materials at all head conditions, as well as all jambs and sills (with dam ends). Sealant alone is not an acceptable means of waterproofing. All metal copings and flashings shall conform to SMACNA construction technical standard manuals.
- **Thermal Barrier:** The building envelope shall include a continuous layer of insulation, in addition to cavity insulation (where cavities exist), consistent with IECC requirements. The Project A/E may be required to provide thermal resistive (R) values for each envelope assembly (including floor slabs) in order to meet sustainability goals and compliance with code. Inert, non-plastic, non-combustible insulating materials are preferred.
- **Air Barrier:** A continuous air barrier is required. Air infiltration rates for air barrier systems must conform to IBC/IECC requirements. The Project A/E may be required to identify the air barrier within the assembly and be prepared to justify barrier system location.
- **Vapor Barrier (Retarders):** Vapor retarders shall be included in all envelope assemblies. A vapor retarder can also function as an air barrier, provided the air barrier is continuous, sealed and is vapor-permeable at rates conforming to the IBC/IECC. Vapor barriers are required at roofs and slabs. Hygrothermal analysis may be required to justify combining air and vapor barrier systems. Climatic conditions may also be considered when selecting a vapor retarder.

5.4 Ceilings

Suspended acoustical ceilings shall have a noise reduction coefficient (NRC) of not less than 0.65 in private offices and conference rooms and 0.75 in open offices, when tested in accordance with ASTM C423, *Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method*. Private offices, conference rooms, and open offices using acoustical cloud or acoustical wall panels with a minimum of 70 percent coverage shall have an NRC of not less than 0.85. Open ceilings are acceptable if noise reduction is considered and the EPA's minimum requirements for noise control (as specified by the EPA Project Manager) are achieved.

Acoustical ceiling tile must meet the California Department of Public Health *Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers*, have a minimum of 30 percent recycled content and have a minimum light reflectance value of 0.85.

5.5 Acoustical Requirements

When separated from adjacent spaces by ceiling high partitions (not including doors), conference rooms shall have a minimum noise isolation class (NIC) of 40 and offices shall have a minimum NIC of 35, when tested in accordance with ASTM E336, *Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings*.

5.6 Flooring

Carpet shall meet the following requirements: adhere to NSF/ANSI 140, *Sustainability Assessment for Carpet,* Gold certification; contain a minimum of 10 percent post-consumer recycled content; and have Green Label Plus certification. Where applicable, other flooring shall meet the following: Cradle to Cradle Certified Product Standard; NSF/ANSI 332, *Sustainability Assessment for Resilient Floor Coverings*; ANSI A138.1, *Green Squared American National Standard Specifications for Sustainable Ceramic Tiles, Glass Tiles, and Tile Installation Materials*; or other multi-attribute standard identified in the federal Green Procurement Compilation. In addition, products shall meet the California Department of Public Health *Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers*.

5.7 Laboratory Doors

Laboratory doors shall be 48 inches wide (36 inches wide for the active leaf and 12 inches wide for the inactive leaf) and 84 inches high to facilitate easy movement of equipment and carts. In general, vision panels shall be provided to allow easy and quick safety inspection of laboratory spaces.

Laboratory doors shall swing in the direction of egress from the laboratory and shall be inserted in alcoves, regardless of the corridor width. Open doors shall not protrude more than 6 inches into exit access corridors. If an existing laboratory is undergoing minor renovations and does not have door alcoves, the laboratory is not required to be reconfigured to meet this requirement.

Laboratory doors are considered high-use doors. Level 1/Light Commercial doors and hardware are not acceptable. All hardware must meet security, accessibility and life safety requirements. Doors shall be fitted with kick plates.

5.8 Architectural Finishes

Vinyl wall coverings shall not be installed on the inside face of exterior walls since the covering will act as a vapor barrier and can cause mold in the wall assembly. Refer to Section 5.3, Building Envelope, within these A&E Guidelines for more information on vapor barriers and envelope assemblies.

5.9 Building Support Areas

5.9.1 Restrooms

The restrooms must be located so that employees will not have to travel more than 150 feet to reach a restroom. Restrooms must conform to ABAAS requirements. All restrooms shall be located along an accessible path of travel. Restrooms shall not be situated adjacent to the queuing/security screening area at the public entrances.

Restrooms shall be equipped with baby changing facilities where required per 40 U.S.C. 3314.

5.9.2 Shower/Locker Rooms

If included in the POR, men's and women's locker rooms with restrooms, shower stalls and adequate lockers shall be provided to encourage staff to bike or walk to work. Locker rooms shall be finished spaces with shower areas separate from the locker areas. Wet locations require all finish material to be installed in conjunction with approved masonry or cementitious backer unit board. Locker rooms shall be provided with resilient flooring and water-resistant wall covering, except in "wet" areas, which shall be finished similar to general use toilets (e.g., ceramic tile floor and walls). See Section 7.7.3, Water Fixtures and Fittings, for shower requirements.

5.9.3 Lactation Rooms

In accordance with 29 U.S.C. 207(r), lactation rooms shall be provided in locations, other than restrooms, that are shielded from view and free from intrusion from coworkers and the public.

5.9.4 Bicycle Storage Facilities

Secure and covered bicycle parking should be provided at each facility. Bicycle parking areas should be in a highly visible and illuminated location, be as close as possible to the main facility entrance(s) and have easy access to shower facilities.

5.9.5 Janitor Closets/Custodial Space

Janitor closets shall be provided in appropriate locations to service the various areas of the building(s). Each floor or block shall have at least one janitor closet with a mop sink and an area to house all necessary supplies. These rooms shall be exhausted to the exterior. Additional custodial space may be necessary for storage of cleaning equipment and supplies.

5.9.6 Equipment Spaces

Mechanical and electrical equipment rooms must be designed with adequate aisle space and clearances around equipment to accommodate maintenance and replacement. Housekeeping pads are required for all floor-mounted equipment. Equipment placement shall allow for the maintenance and removal of motors, coils, other mechanical equipment and filters from the ground. When there is no practicable alternative and equipment must be placed overhead, equipment shall be located such that filter replacement can be safely completed by one person using a standard step ladder. Accommodations for hoists, rails and fasteners for chains shall be provided to facilitate removal of heavy equipment.

Mechanical rooms shall have at least 12 feet of height clearance. All mechanical rooms must be accessible via a freight elevator for O&M and equipment replacement purposes. The freight elevator must be sized to accommodate the largest equipment component. Ship ladders are not permitted as a means of access to mechanical equipment. Mechanical rooms should open from non-occupied spaces such as corridors. If mechanical rooms must open from occupied spaces because of configuration constraints, consider incorporating a vestibule with partitions that extend to the nearest structural walls, with sound/smoke-gasketed doors at each side for acoustic and vibration separation. All equipment spaces must be designed to control noise transmission to adjacent spaces. Refer to Section 7.1.9, Mechanical Rooms, within these A&E Guidelines for additional mechanical room requirements.

The main electrical switchgear shall not be below restrooms or janitor closets, or at an elevation that requires sump pumps for drainage. If electrical switchgear is housed in the basement, provisions shall be made to prevent water from flooding the electrical room in the event of a pipe breaking or flood. Automatic sprinkler piping shall not be installed directly over switchgear equipment.

In areas susceptible to flooding, locate or elevate mechanical and electrical equipment above the local design flood elevation or 3 feet above the base flood elevation (whichever is higher) to protect it from damage during flooding. Consider implementing additional protective measures, such as permanent floodwalls, if necessary.

Walls and ceilings of equipment rooms shall be gypsum board, concrete masonry or other durable surfaces; exposed batt or other forms of insulation shall not be used as wall surfaces. Walls in these areas shall be painted. Floors in mechanical rooms shall be waterproofed. Floors in electrical rooms shall be painted or sealed.

Requirements for telecommunications spaces are detailed in Section 8.8, Telecommunications Systems and Spaces.

5.9.7 Maintenance Shops

Shop facilities shall be located with exterior access appropriate to their function. The shop facilities shall be remotely located away from areas sensitive to vibration, noise and dust. Walls and ceilings of maintenance shops shall be gypsum board, concrete masonry or other durable surfaces; exposed batt or other forms of insulation shall not be used at wall surfaces. Walls in these areas shall be painted. Floors in maintenance shops shall be waterproofed.

5.9.8 General Storage Areas

General storage is usually required on every floor. Adequate storage space must be included in the design. Design considerations include:

- Locate storage internal to the building.
- Size rooms with freezers or other bulky equipment relative to equipment dimensions and layout.
- Ensure good access to service elevator(s).
- Check corridor and elevator dimensions for movement of equipment.

5.9.9 Libraries

Onsite libraries shall be located with suitable access to storage, service elevator(s) and conference facilities. Design considerations include:

- Type of library storage.
- Number of computer terminals/study carrels required.
- Amount of work space required.
- Floor loading/structural requirements.

The Project A/E shall verify library requirements with the EPA Project Manager prior to beginning design.

5.9.10 Records Storage Facilities and Areas

Records storage facilities and areas shall be designed in accordance with the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

5.9.11 Hazardous Materials/Waste Storage Facility

For laboratory facilities, an appropriately sized, isolated hazardous materials/waste storage facility shall be located near the loading dock to facilitate storage and handling of explosive/flammable materials, toxic chemicals, and bio-hazardous waste before transportation and disposal at an offsite location by a licensed contractor. The storage facility shall comply with the EPA Environmental Management Manual, the EPA Safety Manual and the following requirements:

- The storage facility shall be provided with an automatic fire suppression system.
- Only authorized personnel will be permitted entry into limited access or exclusion areas where hazardous materials are housed. Control procedures shall assure positive identification of all personnel prior to entry.
- Doors used for main access to hazardous materials storage structures shall be locked with two high-security locks. Each high-security lock shall be mounted on a high-security, shrouded hasp.
- For FSL-III or higher facilities, hazardous materials storage entryways must be monitored by PACS readers, VSS or IDS (one system minimum per ISC). For FSL-IV facilities, openings of 96 square inches or larger (e.g., windows or hatches) also must be monitored by either VSS or IDS.
- Perimeter lighting shall be positioned and designated to enable the detection of persons in the entire clear zone, inside the inner perimeter fence, between the fences and outside the outer perimeter fence.
- Lighting fixtures shall be positioned to avoid blinding of guards from glare and silhouetting.
- Fresh air intakes shall be provided in conformance with Section 7.3.3, Location of Air Intake(s), within these A&E Guidelines.

5.9.12 Loading Dock/Staging Facilities

Appropriate loading dock/staging facilities are required relative to the facility's size, function and material requirements. Loading docks must be easily accessible by service vehicles, be separated from the main public entrances to the building, be separated from parking access, and be convenient to freight elevators so that service traffic is segregated from the main passenger elevator lobbies and public corridors. Where possible, a one-way design for service traffic to loading and unloading areas is recommended to avoid the need for truck turning areas.

The following minimum requirements shall be applied for loading docks and berths:

- Loading docks must accommodate the vehicles used to deliver or pick up materials from the building. If the bed height of vans and trucks varies more than 18 inches, at least one loading berth must be equipped with a dock leveler. The dock shall be protected with edge guards and dock bumpers. Open loading docks shall be covered at least 4 feet beyond the edge of the platform over the loading berth. In cold climates, dock seals shall be used at each loading bay. Alternatively, consideration could be given to enclosing the entire loading bay. Separate or dedicated loading docks should be considered for food service areas. A ramp shall be provided from the loading dock down to the truck parking area to facilitate deliveries from small trucks and vans. This ramp shall have a maximum slope of 1:12 and comply with ABAAS guidelines, ensuring that deliveries on carts and dollies are maneuverable. If the building size warrants, a dock manager's room or booth should be located so the manager can keep the entire dock area in view and control the entrance and exit from the building. Loading docks must not be used as emergency egress paths from the building.
- The design shall provide at least one off-street berth for loading and unloading. The berth shall be 15 feet wide and at least the length of the longest vehicle to be accommodated. Local zoning regulations or the POR may require a longer length. The space should be located adjacent to the loading dock. If additional loading berths are required, they need not be wider than 12 feet, if they are contiguous to the 15-foot-wide berth. An apron space shall be provided in front of the loading berth for vehicle maneuvering equal to the length of the berth plus 2 feet. This area should be flat with a minimum slope of 1:50 for drainage. The minimum headroom in the loading berth and apron space is 15 feet. When a steeper slope is required in the apron area, the headroom should increase with a gradient allowance to allow trucks to traverse the grade change. If the approach to the loading dock is ramped, the design should permit easy snow removal.
- Fire sprinkler protection in the loading dock area shall be provided in accordance with local and national codes. Additional fire protection specifications are provided in Chapter 10, Fire Protection, within these A&E Guidelines.
- A weather-protected staging area shall be provided inside the building and adjacent to the loading dock. The staging area shall not interfere with emergency egress from the building.
- The loading dock area shall be considered for video monitoring for security purposes.
- The staging and loading area shall include sufficient space for collection and storage of recyclables, compostable material and waste. This space shall be accessible to recycling, compost and waste collection vehicles. See Section 5.9.13, Waste and Recycling Collection/Storage/Staging Areas, below.

5.9.13 Waste and Recycling Collection/Storage/Staging Areas

Management of hazardous waste shall comply with Subtitle C of the Resource Conservation and Recovery Act (RCRA). Refer to the EPA Environmental Management Manual. Management of non-hazardous solid waste shall comply with Subtitle D of RCRA.

The building design shall incorporate adequate space and containers for the collection, storage, and staging of solid waste, recyclable, compostable (where markets exist), and reusable materials generated during building occupancy. Containers may be combined as appropriate where commingled recycling markets exist. The following recyclables (at a minimum) will be collected: mixed paper, corrugated cardboard, glass, metals, plastics, batteries, toner cartridges and "technotrash." The design shall include storage areas for reusable items as needed by the facility (e.g., office supplies, packaging materials, laboratory supplies).

Building corridors, elevators, trash rooms, and/or loading docks shall accommodate collection hampers and containers for aggregating, moving, and temporarily storing solid waste, recyclable, and compostable materials. The loading dock shall accommodate the installation and operation of a compactor(s) as needed for the solid waste and recycling program.

5.10 Laboratory Biosafety Architectural Requirements

The EPA has facilities with up to Biosafety Level 3 (BSL-3) capabilities (defined below). BSL-3 facilities shall be constructed in accordance with the National Institutes of Health (NIH) *Design Requirements Manual* and operated in accordance with the Centers for Disease Control and Prevention (CDC), including the guidelines in the CDC/NIH *Biosafety in Microbiological and Biomedical Laboratories*.

BSL-3 facility design and construction are applicable to clinical, diagnostic, teaching, research or production facilities in which work is done with indigenous or exotic agents that may cause serious or potentially lethal disease through inhalation. *Mycobacterium tuberculosis,* St. Louis encephalitis virus and *Coxiella burnetii* are representative of the microorganism assigned to this level. Primary hazards to personnel working with these agents relate to auto-inoculation, ingestion and/or exposure to infectious aerosols.

At BSL-3, more emphasis is placed on primary and secondary barriers (compared with BSL-1 and BSL-2) to protect personnel in contiguous areas, the community and the environment from exposure to potentially infectious aerosols. For example, all laboratory manipulations shall be performed in a biological safety cabinet or other enclosed equipment such as a gas-tight aerosol generation chamber. Secondary barriers for this level include controlled access to the laboratory and ventilation requirements that minimize the release of infectious aerosols from the laboratory.

5.11 Deconstruction and End-of-Life Structure Management

The facility design should incorporate end-of-life waste prevention strategies for future rebuilds or demolition such as using modular components; designing to standard material sizes; considering prefabricated components; specifying mock-ups for complex, repetitive details; planning for anticipated changes; and material recycling of any construction/demolition waste.

This page intentionally left blank.

6. Structural Requirements

6.1 Design Personnel Qualifications

The person with overall responsibility for the final structural design shall be a registered Professional Engineer in the state where the project will be completed, and all final design drawings shall be sealed by a registered Professional Engineer. Structural engineers shall have a certified Structural Engineer license when required; refer to the requirements of the state in which the project will be completed to determine if a Structural Engineer is required.

6.2 Seismic Design

All projects shall meet, at minimum, all requirements laid forth in:

- IBC.
- NIST *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings: Interagency Committee on Seismic Safety in Construction (ICSSC) Recommended Practice 8*.
- National Earthquake Hazard Reduction Program (NEHRP) *Recommended Seismic Provisions for New Buildings and Other Structures*.
- For existing buildings, ASCE/SEI 41, *Seismic Rehabilitation of Existing Buildings*.

Refer to Section 3.2.3, Geotechnical/Subsurface Investigation, within these A&E Guidelines for information on evaluating seismic activity at a particular location.

6.2.1 Seismic Instrumentation for Buildings

New and existing buildings located in regions of high seismicity, greater than six stories in height, and having an aggregate floor area of 60,000 square feet or greater (and every building located in regions of high seismicity greater than 10 stories in height regardless of floor area) shall have U.S. Geological Survey (USGS)-approved recording accelerographs. The USGS has developed guidelines and a guide specification for the seismic instrumentation of federal buildings. (Refer to M. Celebi, *Seismic Instrumentation of Buildings*, USGS Open-File Report 00-157, April 2000.)

6.3 Floor Loading

The Project A/E shall submit to the EPA Project Manager plans and specifications that show the floor load capacity and are signed and stamped by a registered Professional Engineer (civil or structural specialization). Backup calculations and drawings may also be required to be submitted, on a case-by-case basis.

Floors shall have minimum live load capacities as follows:

- **Office Areas:** Regular office areas shall meet the floor loading capacity as dictated by the regulating code.
- **Laboratory Areas:** The floor shall have a minimum live load capacity of 150 pounds per square foot (lb/ft^2) in both laboratory modules and laboratory storage and receiving areas.
- **Data Center:** Data center rooms shall have a minimum live load capacity of 150 lb/ft^2.
- **Records Storage, Library and High-Density Filing Areas:** Records storage, library and high-density filing areas shall have a minimum live load capacity of 200 lb/ft^2, unless otherwise indicated in the POR.
- **Basements or Lower Levels:** A percentage of the square footage in basements or lower levels shall have a minimum live load capacity of 200 lb/ft^2. This percentage will be specified by the EPA Project Manager for each project.

6.4 Records Storage Facilities and Areas

Records storage facilities and areas shall be designed in accordance with the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

7. Mechanical Requirements

7.1 Mechanical Systems Design Criteria

Building mechanical systems and subsystems shall be evaluated, and major equipment components shall be selected, taking into consideration federal regulations, codes, and executive orders; other health, safety, and sustainability requirements; occupant comfort; attributed atmospheric emissions of regulated air pollutants; and capital, O&M, and life cycle costs.

The following procedures for selection and design of mechanical systems shall be used:

- Ensure that passive design features (e.g., building orientation, shading, building envelope construction, daylighting) are optimized to reduce heating and cooling loads. These passive techniques reduce the requirement to use complex, maintenance-intensive HVAC systems and equipment, thus reducing both energy usage and life cycle costs.
- Design mechanical systems with special emphasis on simplifying controls, operations and maintenance. In general, the least complex of the technically feasible and cost-effective alternatives should be selected based on functional requirements, ease of maintenance and the design energy budget. In other words, a system requiring extensive use of complex systems and controls should only be considered when there are no practical alternatives to obtain the design energy budget.
- Consider available resources utilized to maintain mechanical systems when selecting the system design and capabilities. The facility staff shall be trained to understand the operating principles, control logic and maintenance of the system. The EPA Project Manager may specify that the equipment supplier provide additional training for facility O&M staff.
- Ensure that adequate space will be provided for equipment maintenance and removal/replacement.

7.1.1 Life Cycle Cost Analyses

LCCAs shall be performed using NIST Handbook 135, *Life Cycle Costing Manual for the Federal Energy Management Program,* to select the most cost-effective system(s) and components. (Refer to Section 1.5, Energy and Water Efficiency – Life Cycle Cost Analyses, within these A&E Guidelines for additional information on conducting LCCAs.)

The LCCA models utilized to evaluate the mechanical systems must allow for sensitivity evaluations on design parameters (e.g., pipe size, chiller capacity, condenser water leaving temperature, cooling tower size) in order to identify the most cost-effective and feasible alternative.

7.1.2 Energy Efficiency

For new construction and major renovations, the design shall meet or exceed ASHRAE Standard 90.1 and the energy performance level required by the *Guiding Principles for Sustainable Federal Buildings*, 10 CFR 433 (as required for new construction) and any other federal mandates.

42 U.S.C. 8259(b) also requires that, when procuring energy-consuming products, all federal agencies procure products that either are ENERGY STAR certified or meet FEMP minimum efficiency requirements, unless it can be demonstrated that products meeting the requirements of ENERGY STAR or FEMP are not "reasonably available." Product requirements under both programs can be found at: http://energy.gov/eere/femp/find-product-categories-covered-efficiency-programs.

7.1.3 Computational Fluid Dynamics Modeling

Computational fluid dynamics (CFD) models shall be considered for predicting indoor air quality parameters in spaces with complex airflow regimes and/or potentially hazardous conditions. For the EPA, the most likely application will be modeling airflows, contaminant concentrations, and other factors that influence the selection and design of fume hoods and laboratory ventilation systems.

7.1.4 Wind/Air Flow Modeling

When requested by the EPA, a study shall be conducted to determine the location and design of fresh air intakes, exhaust stacks and emergency generator exhaust to avoid adverse air quality impacts. The study shall utilize recognized wind modeling techniques, such as the EPA's Industrial Source Complex Model (ISC3) and the Briggs Plume Rise Equations, and the design criteria of the *ASHRAE Handbook—Fundamentals* and the *ASHRAE Handbook—HVAC Applications*, as applicable. In addition, the study shall take into consideration the recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) *Industrial Ventilation: A Manual of Recommended Practice for Design*, as applicable.

7.1.5 Outdoor Design Conditions

Outdoor air design criteria shall be based on weather data tabulated in the *ASHRAE Handbook—Fundamentals*. The Project A/E shall verify outdoor design conditions with the EPA Project Manager.

7.1.6 Indoor Temperature and Humidity Requirements

Design temperatures shall conform to ASHRAE Standard 55. Temperatures shall be maintained throughout occupied spaces, regardless of outside temperatures, during the hours of normal operation of the facility.

Seasonal design relative humidity values shall be as follows, unless otherwise designated by the project requirements:

- **Conformance With ASHRAE:** Except where indicated differently, relative humidity levels for each season shall be maintained in accordance with the *ASHRAE Handbook—Fundamentals.*
- **Cooling Season:** The design relative humidity shall be 50 percent. Summer humidification shall not be provided for personnel comfort. Cooling systems shall be designed to maintain the relative humidity conditions of the space through the normal cooling process.
- **Heating Season:** In laboratory spaces, winter humidification for personnel comfort and health shall not be provided due to the difficulty and expense of providing humidification, unless it can be substantiated from records or engineering computations that the indoor relative humidity will be less than 30 percent. Where the probable occurrence of these conditions has been substantiated, a design relative humidity of 30 percent shall be used in establishing minimum requirements for humidification equipment. Humidification for office spaces will be considered on a case-by-case basis.

7.1.7 Balancing Devices

The Project A/E must specify the components necessary to test and balance the HVAC system in accordance with SMACNA, ASHRAE, AABC and NEBB standards.

7.1.8 Service Access and Clearances

Sufficient horizontal and vertical clearances shall be provided around all HVAC system equipment, as recommended by the manufacturer and in compliance with code requirements for routine maintenance and equipment replacement. Access doors or panels shall be provided for ventilation equipment, ductwork and plenums to facilitate inspection and cleaning.

Mechanical equipment rooms shall have clear ceiling heights of at least 12 feet. Catwalks with stairways shall be provided per OSHA requirements for all equipment that cannot be maintained from floor level. Where maintenance requires the lifting of heavy parts (100 pounds or more), hoists and hatchways shall be installed.

Mechanical rooms shall be configured with clear circulation aisles and adequate access to all equipment in accordance with manufacturers' recommendations and applicable standards. Mechanical rooms shall have adequate doorways (or areaways) and staging areas to permit the replacement and removal of equipment without the need to demolish walls or relocate other equipment. Sufficient space for maintenance and removal of coils, filters, motors and similar devices shall be provided in accordance with the manufacturers' recommendations.

Chillers shall be located to permit pulling of tubes from all units. The clearance shall equal the length of the tubes plus 2 feet. Air handling units (AHUs) require a minimum clearance of 2.5 feet on all sides, except the sides on which filters and coils are accessed, where a 2-foot clearance is acceptable.

Access to roof-mounted equipment shall be provided via stairways and per code.

7.1.9 Mechanical Rooms

All mechanical rooms must be mechanically ventilated to maintain room space conditions, as indicated in ASHRAE Standard 62.1 and ANSI/ASHRAE Standard 15, *Safety Standard for Refrigeration Systems*. Locations and characteristics of water lines shall comply with the requirements of NFPA 70. Mechanical rooms shall have floor drains in proximity to the equipment they serve, to reduce water streaks or drain lines extending into aisles. (Floor drains shall discharge to the facility's industrial/process sewer system, and not to any storm drains). Mechanical rooms shall not be used as return air, outdoor air or mixing plenums.

Rooms that house emergency generators shall meet the requirements of NFPA 110, *Standard for Emergency and Standby Power Systems*, and meet the combustion air requirements of the equipment, OSHA requirements, and state and local air emissions/air quality regulations. These rooms must be ventilated sufficiently to remove heat gain from equipment operation and maintain ambient temperature requirements during operations (including periodic turn-over testing and idling). Supply and exhaust louvers shall be located to prevent short-circuiting of airflow. Generator exhaust shall be carried up to the roof level in a flue that is constructed and installed in conformance with the manufacturer's recommendations and local code requirements. Horizontal exhaust through a building wall must be approved by the EPA Project Manager.

7.1.10 Refrigerants

Use of ozone-depleting substances and high global warming potential hydrofluorocarbons is prohibited. The Project A/E shall select refrigeration and air conditioning equipment that uses refrigerants identified by the EPA's Significant New Alternatives Policy (SNAP) program as alternatives to ozone-depleting substances and high global warming potential hydrofluorocarbons. Refer to the EPA's SNAP program for the list of alternatives, available at 40 CFR 82, Subpart G, as well as http://www.epa.gov/snap.

7.1.11 Insulation

Field-applied insulation shall be provided for HVAC air distribution systems and heating, hot water, and chilled water piping systems in accordance with ASHRAE standards and the IECC. Insulation shall:

- Be provided and installed in accordance with the Midwest Insulation Contractors Association *National Commercial & Industrial Insulation Standards*.
- Have thermal resistance values that meet or exceed the minimum requirements per the IECC.
- Be chlorofluorocarbon (CFC)- and hydrochlorofluorocarbon (HCFC)-free.
- Meet the minimum recycled content levels required by the EPA's Comprehensive Procurement Guidelines, where applicable.

7.1.12 Biosafety in Microbiological and Biomedical Laboratories

Special design criteria are required for BSL laboratories. The Project A/E shall work with EPA SMEs to determine design requirements.

7.1.13 Records Storage Facilities and Areas

Records storage facilities and areas shall be designed in accordance with the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

7.2 Ventilation Systems

Within this section, Sections 7.2.1 through 7.2.8 contain general requirements for ventilation systems at all types of EPA facilities. Additional, specialized requirements for laboratory ventilation systems are discussed in Sections 7.2.9 and 7.2.10. Non-laboratory spaces shall comply with the requirements of ASHRAE Standard 62.1.

7.2.1 Duct Design

General Requirements

Ductwork systems shall be designed for efficient distribution of air to and from the conditioned spaces.

As described in Chapter 10, Fire Protection, within these A&E Guidelines, duct smoke detectors shall be installed in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*.

Ductwork systems shall be designed to meet the leakage rate requirements of the SMACNA *HVAC Air Duct Leakage Test Manual*.

Ductwork, accessories and support systems shall be designed to comply with the following:

- ACGIH *Industrial Ventilation: A Manual of Recommended Practice for Design*.
- ANSI/American Industrial Hygiene Association (AIHA)/American Society of Safety Professionals (ASSP) Z9.2, *Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems*.
- ANSI/AIHA/ASSP Z9.5, *Laboratory Ventilation*.
- ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*.
- *ASHRAE Handbook—Fundamentals*.
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*.
- NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*.
- NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*.
- SMACNA 1520, *Round Industrial Duct Construction Standards*.
- SMACNA *Fibrous Glass Duct Construction Standards*.
- SMACNA *HVAC Duct Construction Standards—Metal and Flexible*.
- SMACNA *HVAC Systems Duct Design*.

Insulation

All supply air ductwork shall be insulated with a vapor barrier, unless otherwise dictated by the project criteria. Supply air ductwork installed below ceilings and in conditioned spaces may not require insulation if the surrounding air has a sufficiently low dew point such that condensation will not occur (as verified by engineering calculations). Return and exhaust air ductwork that runs through unconditioned space shall be insulated if condensation may occur, or if an energy recovery system is in place. In laboratories, insulation shall not be installed inside ductwork.

Air Distribution

Supply, return and exhaust air ducts shall be designed and constructed to allow no more than 3 percent leakage of total airflow in systems up to 3 inches of water column (in WC) pressure. In systems that operate between 3 in WC and 10 in WC, ducts shall be designed and constructed to limit leakage to 0.5 percent of the total airflow. All ductwork joints and all connections to air handling and air distribution devices shall be sealed with mastic, including all supply and return ducts, any ceiling plenums used as ducts, and all exhaust ducts. Energy consumption, security, and sound attenuation shall be major considerations in the routing, sizing, and material selection for the air distribution ductwork.

Ductwork Pressure and Velocity

Ductwork shall be designed in accordance with the *ASHRAE Handbook—Fundamentals* and constructed in accordance with the *ASHRAE Handbook—HVAC Systems and Equipment* and the SMACNA Design Manuals.

The duct network shall be pressure-tested after installation. The maximum acceptable leakage rate is defined in the SMACNA *HVAC Air Duct Leakage Test Manual*.

7.2.2 Air Handling Units

Access Doors

AHUs are confined spaces per OSHA regulations in 29 CFR 1910.146, *Permit-Required Confined Spaces*. Special safety precautions are therefore necessary before personnel attempt to access an AHU for inspection or servicing. All access doors to AHUs shall be labeled, "Confined Space—Do Not Enter Without Proper Permits and Safety Procedures." Access doors shall comply with applicable NFPA standards, the IBC, and local fire codes if more stringent.

Condensate

Reuse of condensate from AHUs (and the entire air handling system) shall be considered, particularly in geographic locations with extended periods of warm, humid climatic conditions. In applications where AHU condensate reuse is life cycle cost-effective, it shall be implemented. Condensate recovery is discussed in greater detail in Section 7.5.1, Energy and Water Efficiency, within these A&E Guidelines.

Terminal Units

Variable air volume (VAV) terminals shall be certified under the ANSI/Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 880 Certification Program and shall carry the ANSI/AHRI Seal. If fan-powered, the terminals shall be designed, built, and tested as a single unit, including the motor and fan assembly, primary air damper assembly, and any accessories. VAV terminals shall be pressure-independent type units. Air leakage from the casing of each individual VAV box/terminal shall not exceed 2 percent of its rated capacity. Units shall have self-contained controls that are compatible with the BAS as described in Chapter 9, Building Automation Systems, within these A&E Guidelines. Fan-powered terminals shall be equipped with ducted returns, featuring a filter/filter rack assembly with MERV 10 filters. The return duct shall be covered on all externally exposed sides with a minimum of 2 inches of insulation. Fan-powered terminals shall have electronically commutated motors for speed control to allow continuous fan speed adjustment from maximum to minimum, as a means of setting/adjusting the fan airflow.

The return plenum box for fan-powered terminals shall be a minimum of 24 inches in length and shall be double-walled (with insulation in between) or contain at least one elbow, where space allows. Fan-powered terminals may have hot water heating coils used for maintaining temperature conditions in the space under partial load conditions. However, fan-powered terminals located in proximity to the perimeter zones and on the top floor of the building shall always contain hot water coils for heating.

7.2.3 Fans

Fans shall be designed and specified to ensure stable, non-pulsing and aerodynamic operation in the design range of operation, over varying speeds. Fans with motors of 20 horsepower (hp) or less shall be designed with adjustable motor pulley sheaves to assist in air-balancing the fan. Fans with motors of greater than 20 hp shall use fixed (non-adjustable) drives that can be adjusted by using fixed motor pulley sheaves of different diameters. Supply AHUs and return air fans in VAV systems shall control capacity using variable-speed drives. All fans shall comply with the following:

- ANSI/Air Movement and Control Association (AMCA) Standard 210, *Laboratory Method of Testing Fans for Certified Aerodynamic Performance Rating*.

- *ASHRAE Handbook—HVAC Systems and Equipment*.
- ACGIH *Industrial Ventilation: A Manual of Recommended Practice for Design*.

Fans shall be located in accordance with the requirements of AMCA 201. Motors shall be sized according to properly calculated brake horsepower (bhp) fan requirements. (Do not specify “oversized” fans and motors to meet future capacity needs unless directed to by the project criteria.) Fan construction materials shall be selected based on corrosion resistance, structural integrity/fatigue resistance over the required performance period and cost.

Spark-resistant materials shall be used where required by NFPA standards. All fans and accessories shall be designed and specified to meet all requirements of NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, regarding controlling spread of smoke and flame. Smoke detectors for automatic control in air distribution systems shall be located in accordance with the requirements of NFPA 90A.

7.2.4 Under-Floor Air Distribution Systems

All under-floor air distribution (UFAD) systems shall be designed in accordance with the ASHRAE *UFAD Guide*. Areas to be considered for UFAD systems should be carefully evaluated on a case-by-case basis. UFAD systems shall not be installed in any laboratory spaces, unless approved by the EPA Project Manager.

7.2.5 Exhaust Air Energy Recovery

The Project A/E shall consider exhaust air heat recovery systems such as:

- Rotary air wheels/enthalpy wheels (can be considered under certain circumstances, but not in chemistry laboratory applications; consult the EPA Project Manager).
- Air-to-air heat exchangers.
- Heat pipes.
- Run-around systems (closed loop and open loop).
- Air-to-water heat pumps.

7.2.6 Fire and Smoke Dampers

Fire and smoke dampers must be installed to meet all code, NFPA, ASHRAE and SMACNA requirements.

7.2.7 Demand-Controlled Ventilation and Carbon Dioxide Monitoring Equipment

Demand-controlled ventilation (DCV) shall be provided in high occupancy zones (e.g., conference rooms, training rooms) and remote ventilation zones (e.g., storage rooms), and shall be compliant with ASHRAE Standard 62.1. The DCV system shall be integrated with the BAS and include carbon dioxide (CO_2) sensors for interior (between 3 feet and 6 feet above the floor) and exterior measurements. Laboratory facilities shall not be equipped with DCV in any spaces (including support spaces) without the EPA Project Manager’s approval.

DCV systems generally should be sized based on the peak occupancy of the space or zone and allow ventilation rates to vary, depending on occupancy. This will maximize energy savings while also ensuring that spaces can be rapidly purged (and required air quality levels restored) upon resumption of occupancy. Ventilation systems that are downsized based on less than 100 percent diversity may not be capable of purging all required zones quickly enough, and thus are not recommended in DCV applications. (Note: Systems with airside economizers already have the capability to rapidly introduce outdoor air into the HVAC system, and thus could potentially be downsized. Evaluate these systems on a case-by-case basis).

Contaminants shall be controlled at the source in such a manner that the following indicator levels for carbon monoxide (CO), CO_2 and formaldehyde (HCHO) are not exceeded:

- **CO:** 2 parts per million (ppm), 8-hour time weighted average (TWA).

- **CO_2:** 1,000 ppm, TWA (maximum); 850 ppm, TWA (recommended).
- **HCHO:** 0.05 ppm, TWA.

The DCV system shall regulate outside air ventilation such that, in office facilities, occupied space CO_2 is maintained to no more than 650 ppm above outside air conditions. CO and pressure differential monitoring shall be connected to the BAS for all spaces adjacent to (above, below or to the side of) automobile, truck or other sources of combustion byproducts idling.

7.2.8 Exhaust and Pressurization for Areas With Battery Storage, Hazardous Gases or Chemicals

Where battery storage, hazardous gases, or chemicals may be present or used (including garages, housekeeping/laundry areas, and copying/printing rooms), each space shall be sufficiently exhausted to create a negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, self-closing doors shall be provided, and the space shall have either deck-to-deck partitions or a hard lid ceiling. The exhaust rate shall be at least 0.5 cubic feet per minute (cfm)/ft^2, with no air recirculation.

7.2.9 Laboratory Ventilation Systems

General Requirements

Occupant health and safety shall be the primary and overriding goal of all laboratory ventilation systems. Therefore, laboratory ventilation systems must function effectively in conjunction with all fume hoods and associated exhaust systems (Refer to Section 7.2.10, Laboratory Fume Hoods, of these A&E Guidelines). Maintaining comfortable interior temperature and humidity levels—to the extent possible given variation in occupant preferences—is also a critical goal for ventilation system design.

HVAC systems for the sections of laboratory buildings, including corridors, where the laboratory and laboratory support rooms are located shall be designed to provide 100 percent dedicated outside air systems (DOASs), with the exhaust directed through fume hoods (where fume hoods are present) and general exhaust ductwork. Under no circumstances will the air supplied to any laboratory space be re-circulated to any other space.

The Project A/E shall assume that the majority of the HVAC systems at EPA laboratories must be continuously operational (i.e., 24 hours a day, seven days a week, 365 days a year). However, the Project A/E shall work with EPA SMEs to determine if 24-hour operation is required or an alternate operational mode will suffice.

Laboratory spaces shall be designed to maintain a pressurization level relative to other common spaces that is appropriate for the type of work performed in each laboratory and is negative to the laboratory corridor and non-laboratory spaces. The levels of pressurization shall be project-specific and shall be determined in accordance with ANSI/AIHA/ASSP Z9.5.

Certain areas (e.g., at or in proximity to fume hoods) may require emergency manual override controls, which increase fresh supply airflow and simultaneously increase negative pressurization. The HVAC systems that serve those laboratory area(s) shall be capable of managing the increased airflow during emergency override conditions. If the exhaust airflow will exceed the supply airflow when the emergency override mode is in effect, a delay period of 30 to 60 seconds (this is adjustable based on the facility's layout) after triggering the evacuation alarm shall be programmed into the system. This will aid occupants in evacuating the space before the doors become too difficult to open.

Design Guidelines

The Project A/E shall optimize the laboratory ventilation rates based on room geometry, research activities, solutions derived from risk hazard assessment findings, occupancy schedules and other parameters (as opposed to using a fixed number of air changes per hour [ACH] or fixed volume flow [i.e., cfm/ft^2]). This position has been endorsed by numerous governmental and technical advisory bodies, including ANSI, AIHA and ACGIH. Key considerations for the design of laboratory ventilation systems shall include:

- Determine air change rates in the laboratory modules on a project-specific basis. The Project A/E shall work with EPA SMEs to determine the correct classification of the laboratory module space and the corresponding requirement for air change rates.
- Perform before or during design a risk hazard assessment of the laboratory areas being affected by construction or renovation to determine the ability to reduce energy consumption and to identify appropriate equipment needed for hazardous elements handled at the facility. Airflow reductions and operational setting changes (e.g., occupied/unoccupied modes, fume hood retrofits, ACH change) must be approved by the EPA Safety and Sustainability Division.
- Follow all relevant provisions of the IBC, as well as federal, state, or local regulations and codes, that are more stringent than the guidelines and requirements referenced herein. Where such codes are judged outdated or unduly restrictive, a variance should be sought from the applicable agency.
- Avoid excessive supply airflows. They can result in higher concentrations of airborne contaminants by increasing the quantities partitioned into the air and subsequent dispersion within the room.
- Evaluate the mixing properties of any contaminants of concern that might be inadvertently spilled or released within the laboratory space. CFD modeling may be required to assess the time-dependent dispersal of contaminants. Instantaneous concentrations generated by the model shall be compared with applicable OSHA or ACGIH health-based standards (e.g., permissible exposure limits, threshold limit values) and action levels (e.g., immediately dangerous to life or health [IDLH] concentrations).
- Consider hazardous chemical control banding to ensure that operations are segregated or grouped to use the minimum safe ventilation rates for each band. Control bands are determined by a chemical's (1) relative toxicity; (2) quantities used/"scale" of the process; and (3) tendency to become airborne under conditions likely to occur routinely at the laboratory. Control banding also can be used for selection of fume hoods (refer to Section 7.2.10, Laboratory Fume Hoods, of these A&E Guidelines) and to determine which processes require even greater isolation (e.g., glove boxes).
- Rather than over-sizing the primary supply and exhaust systems, include appropriate emergency override ventilation systems, as previously described.
- Identify all temperature control zones within each laboratory module (or laboratory wing) and connect sensing components to the existing or new BAS for monitoring and control.
- Determine if the laboratory will be required to coordinate and handle ultra-dilute reference samples of chemical agents for the U.S. Department of Homeland Security.
- Consider location, quantity and specific room layout requirements to minimize post-installation issues such as excessive supply airflow and cross drafts. See *EPA Performance Requirements for Laboratory Fume Hoods* Section 4-2 for more information.
- Consider chilled beams and other sensible cooling equipment for laboratory modules with extreme internal heat loads.
- Identify all components of the laboratory ventilation system that require emergency power.

Setback Mechanism

A setback mechanism shall be included (e.g., sash switch or equal), which provides a low-speed operations setting for fume hood exhaust and supply airflow control valves. The setback mechanism shall be designed to provide, when the sash is fully closed, a minimum of 4 ACH (a lower ACH level may be approved by the EPA Project Manager and the EPA Safety and Sustainability Division). The exhaust requirements of fume hoods and other exhaust devices, as well as the temperature and humidity requirements, shall override laboratory minimum ACH. The decrease in exhaust volumes and ACH must be balanced by an appropriate reduction in supply air/AHU fan speeds, to maintain negative pressure requirements inside the laboratories and laboratory support rooms, with respect to corridors and other non-laboratory spaces. The HVAC system(s) nighttime setback shall be controlled by the BAS.

7.2.10 Laboratory Fume Hoods

Laboratory fume hoods (hereafter “fume hoods”), as constructed, manufactured, installed and used, shall conform to current EPA design, testing, safety, health and environmental requirements. The Project A/E, EPA Project Manager, EPA Facility Manager and EPA Safety and Sustainability Division SME shall coordinate and be responsible for selecting fume hood types and sizes that are appropriate to the intended uses. A current list of fume hood models that meet the *EPA Performance Requirements for Laboratory Fume Hoods* “As Manufactured” tests can be obtained from the EPA Safety and Sustainability Division. Specialty fume hoods presenting extreme hazards (e.g., perchloric acid fume hoods) must follow federal, state, and local regulations and codes. Fume hoods shall be considered an integral part of the overall building HVAC system and shall be included in TAB activities and approved by the EPA Project Manager and EPA Safety and Sustainability Division prior to fume hood testing and building acceptance.

Basic Fume Hood Requirements

Generally, the EPA requests high performance fume hoods (e.g., those designed to operate in the range of 60 to 70 feet per minute [fpm], compared with conventional fume hoods, which operate at 90 to 110 fpm), where practicable. EPA fume hoods shall meet all design and performance criteria set forth in the *EPA Performance Requirements for Laboratory Fume Hoods*.

In accordance with ANSI/AIHA/ASSP Z9.5, the flow rate of constant volume fume hoods and the minimum flow rate of VAV fume hoods shall be sufficient to prevent hazardous concentrations of contaminants within the fume hood. In addition to maintaining proper hood face velocity, fume hoods shall maintain a minimum exhaust volume to ensure that contaminants are properly diluted and exhausted from the fume hood. The Project A/E may increase the minimum fume hood flow rate if the ventilation equipment and the airflow control system cannot regulate room air rates at the values required to effectively pressurize the room.

At a minimum, the following considerations shall be implemented for projects that involve fume hood selection, design or installation:

- Identify any user-specific needs for fume hood environmental monitoring (refer to the EPA Environmental Management Manual).
- Identify any facility-specific containment requirements.
- Prior to fume hood selection, conduct analyses to potentially reduce the number of hoods needed and to explore energy conservation measures (e.g., occupancy modes). Also, conduct a retrofit evaluation to determine if new fume hoods or fume hood retrofits are needed. Retrofits include, but are not limited to, airfoil retrofit packages and bypass perforated grills, which increase performance in older fume hoods and reduce energy consumption.
- Determine the quantity, type and size of fume hoods needed to perform laboratory operations.
- Identify if constant (full bypass) or VAV (partial bypass) fume hood controls are to be used.
- Analyze expected laboratory space airflow dynamics to evaluate whether airflow tracking, active pressurization control or a combination of both is required.
- Locate fume hoods such that no structure or other equipment obstructs the airflow into the hood, potentially affecting the performance (e.g., away from entry doors, exits or other laboratory equipment).

- Analyze the effects of cross-draft velocities, room diffuser type(s) and diffuser location(s) when evaluating whether a fume hood(s) design configuration and operating parameters will ensure effective contaminant containment.[2]

- Select and locate ceiling and wall diffusers for the distribution of supply air in the laboratory in a manner such that the air velocity at the face of the fume hood does not exceed 30 fpm in any direction. Diffusers shall (1) be located at least 5 feet from the face of any fume hood; (2) be located to the side of the hood rather than in front of the hood; (3) shall not "short circuit" the airflow to a fume hood; and (4) shall not blow directly on fire, vapor or radioactivity detectors. During the design and selection of diffusers, the goal is to minimize contaminant(s) mixing and maximizing contaminant removal. Laminar discharge is recommended.

- Determine the failure mode of all terminal boxes to ensure that the laboratory pressurization criteria are met under all anticipated operating conditions.

- Confirm that laboratory temperature control does not override the minimum fume hood ventilation requirements.

- Ensure materials used in the construction of fume hoods and of associated fans meet corrosion resistance standards for the chemicals used and generated in the hood.

- Specify fans that are rated or otherwise approved for use by a recognized certifying body. Plumbing fixtures and electrical outlets must meet existing codes.

- Equip the fume hood sash with a control device to maintain it at the operating height (e.g., releasable sash stops). Automatic sash closers are recommended.

- Equip all fume hoods with a low-exhaust flow alarm system designed to signal unsafe operating conditions whenever the average face velocity decreases. The alarm system shall consist of an audible and visual alarm to indicate malfunction or unsafe operating conditions. The alarms shall be calibrated to alert when the average face velocity of air drops below the specified low-end passing range value in fpm (i.e., 60 fpm for a high-performance low-flow fume hood and 90 fpm for a traditional low-flow fume hood). The monitor shall display face velocity quantitatively with a minimum accuracy of ±5 percent of the average face velocity. The monitor's digital display and alarm conditions shall be clearly visible in the installed location.

- Ensure the noise exposure at the working position in front of the fume hood does not exceed 70 A-weighted decibels (dBa) with the system operating and the sash open. The noise exposure also shall not exceed 55 dBa at bench-top level elsewhere in the laboratory room. Each new fume hood installation shall be certified as meeting this requirement before initial use and shall be recertified annually thereafter. Fans used in the exhaust systems servicing fume hoods shall be low-noise generating and corrosion-resistant to the fumes generated inside the fume hood. Total room performance with respect to noise levels must not exceed the permissible exposure limits specified in 29 CFR 1910.95.

- Confirm satisfactory performance testing of potential fume hood and control system configurations in accordance with ANSI/AIHA/ASSP Z9.5, ANSI/ASHRAE Standard 110 and the *EPA Performance Requirements for Laboratory Fume Hoods*. All fume hoods must be capable of passing the *EPA Performance Requirements for Laboratory Fume Hoods* "As Manufactured," "As Installed" or "Annual" test criteria.

- Certify that biological safety cabinets meet minimum standards as established by NSF/ANSI 49, *Biosafety Cabinetry Certification*.

2 Smith, T.C. and N. Paschke, Investigating Fume Hood Performance as a Function of Laboratory Air Supply, Labs21 2007 Annual Conference, www.i2sl.org/elibrary/smith2007.html.

Fume Hood Exhaust Systems

Fume hood exhaust systems shall be designed in accordance with the ACGIH *Industrial Ventilation: A Manual of Recommended Practice for Design*; ANSI/AIHA/ASSP Z9.5; and NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*. Dedicated exhaust systems shall be provided for fume hoods when:

- The mixing of emissions from the individual hoods is inadvisable; or
- The emissions must be filtered, scrubbed or otherwise treated before discharge.

Perchloric acid fume hoods shall have dedicated exhaust systems that comply with ANSI/AIHA/ASSP Z9.5.

Pressure in laboratories shall be maintained as negative with respect to adjacent areas, unless positive pressure is required for the research conducted in the laboratory module.

Fume hood and equipment exhaust manifolds shall be constructed from polyvinyl chloride (PVC)-coated galvanized sheet metal or Type 316 welded stainless steel, depending on the physical and chemical characteristics of the exhaust. Specialty duct materials shall be considered for highly corrosive exhaust applications. Exhaust ductwork from fume hoods shall not be of spiral construction and shall be sloped toward the hood for drainage of condensate. Fume hood exhaust ducts shall also be constructed with welded longitudinal seams and welded transverse joints, or equivalent construction, in accordance with the requirements of ANSI/AIHA/ASSP Z9.2. Fume hood ductwork also shall be installed in accordance with the requirements of NFPA 45, specifically:

- Both new and remodeled fume hoods shall be equipped with flow-measuring devices.
- Air exhausted from fume hoods shall not be re-circulated into the workspace or any other space within the building.
- Air from laboratory units and laboratory work areas in which chemicals are present shall be continuously discharged, and the exhaust systems shall be maintained at a negative pressure (i.e., lower pressure than the pressure in normally occupied areas of the building).

Wherever feasible and cost-effective, exhaust fans associated with fume hoods shall be equipped with variable-speed drives (also known as variable-frequency drives for AC-powered systems). Exhaust fans shall also be equipped with static pressure reset controls for off-hours operation.

Consistent with ANSI/AIHA/ASSP Z9.5, exhaust from laboratory ductwork systems must be discharged in a location(s) and manner to avoid re-entry into the laboratory building (or entry into adjacent buildings) at concentrations above 20 percent of the allowable concentrations inside the laboratory (or adjacent buildings). To optimize the effective stack height and exit discharge velocities at the required exhaust flow rate(s) and to ensure that these requirements are met under any wind or atmospheric conditions, the EPA Project Manager may require that an air re-entrainment analysis be performed. Fume hood exhaust stacks shall be constructed without caps, rain hats or other covering, as these can reduce exhaust plume buoyancy.

Also note that, while commonly used EPA screening models (e.g., SCREEN3) are relatively simple to apply and produce results rapidly, there are documented limitations to their ability to simulate downwash and wake effects due to structures within close proximity to the exhaust stack(s). For this reason, the application of CFD models (and in certain complex cases, scale-model wind turbine simulations) may be required to ensure that downstream contaminant concentration limits established by ANSI/AIHA/ASSP Z9.5 will be achieved.[3] (CFD modeling requirements are covered in Section 7.1.3, Computational Fluid Dynamics Modeling, within these A&E Guidelines.) If an air re-entrainment analysis is not required, the exhaust stack shall extend a minimum of 10 feet above the adjacent roof level and operate at an exhaust discharge velocity as necessary to meet ASHRAE requirements.

For fume hoods in areas designated as Group H-5 in accordance with the IBC, emergency power systems must be installed. In addition, the exhaust ventilation system shall be designed to operate at a minimum of 50 percent of

3 Petersen, R.L., B.C. Cochran, and J.W. LeCompte, Specifying Exhaust Systems that Avoid Fume Reentry and Adverse Health Effects, ASHRAE Transactions, Vol. 108, Pt. 2, 2002.

the normal fan speed while on emergency power, or at a higher rate if necessary to comply with safety, health and environmental requirements.

Manifolding of Fume Hood Exhausts

Fume hood exhausts shall be manifolded per NFPA 45. Manifolded exhaust systems (where used) shall incorporate staged, multiple fans with variable-speed drives and control dampers to maintain a constant static pressure in the manifold. This type of configuration ensures a quick response to changing conditions within the fume hoods.

Fume Hood Emissions Controls

In most situations, the exhaust from chemicals will be diluted enough and/or will be in quantities small enough to be exempt from Clean Air Act (CAA) regulations. However, local, state and EPA requirements shall always be reviewed for any construction project that will add fume hoods. The aggregate amount of emissions from the facility and/or the quantities and rates of emission from fume hoods in certain cases may trigger (or contribute to existing) permitting requirements under Title V of the CAA or rules governing minor (non-Title V) sources. Additional information regarding potential CAA requirements for fume hoods and associated exhaust systems is provided in the EPA Environmental Management Manual.

If emissions controls are required, appropriate control devices (e.g., particulate filters, HEPA filters, scrubbers, activated carbon canisters) shall be installed. Equipment that condenses, traps, neutralizes or polymerizes[4] the hazardous substance(s) before it exits the fume hood shall be considered where feasible, because the quantity of waste requiring disposal will typically be 100 to 1,000 times less than that associated with capturing the contaminant from the airborne exhaust with a scrubber or activated carbon bed.[5]

At a minimum, the following considerations shall be implemented for any design that uses scrubbers:

- Scrubbers shall be configured with countercurrent flow between the airstream and the reagent to maximize removal efficiency. Scrubbing liquid shall be captured in a sump below the scrubber, and a recirculation system (pump and piping) shall be provided to aid in conserving the reagent chemical. The following sensors and controls shall be provided:
  - A liquid level sensor and controls on the sump to initiate make-up water flow at low level and shut down airflow at high level.
  - A pH probe and controller to trigger additional reagent chemical flow when required.
  - A conductivity meter and controls that measures total dissolved solids and activates a blowdown valve to drain excess salts.
- An in-line filter also shall be provided in the recirculation loop to remove particulates that are likely to be captured by any scrubber (in addition to the targeted chemical[s] of concern).
- Scrubbers for control of corrosive fumes shall be located as close as possible to the fume hood(s) or be constructed of a suitable corrosion-resistant material.
- A pipe wash-down sequence and procedure shall be incorporated in the design of the scrubber system. Nozzle placements and spray coverage shall ensure all inside surfaces of the duct are wetted/rinsed during the procedure.
- All floor drains in the room in which the scrubber system resides shall run to the acid waste system.

Activated carbon beds shall be equipped with sampling ports to aid in assessing when contaminant breakthrough has occurred (or better breakthroughs are about to occur). The O&M manual for the carbon beds shall also specify the expected life to break-through at various concentrations and exhaust airflow rates for the contaminants of

4 Using an initiator compound to convert a substance to a solid or gel with low vapor pressure (e.g., acrylonitrile).

5 Hitchings, D.T., Fume Hood Scrubbers, SAFELAB Corporation, September/October 1993.

concern. Used carbon shall be disposed, where necessary as hazardous waste, in accordance with the EPA Environmental Management Manual.

Unless otherwise directed by the EPA Project Manager, HEPA filters will be required to manage exhaust from fume hoods in which radiological, bio-hazardous or chemical agents are handled. HEPA filter housings shall be designed to minimize any possible contact or exposure to the contaminants of concern during filter change-outs. Guidance on the selection and design of radioactive air-cleaning devices can be found in the DOE *Nuclear Air Cleaning Handbook* and in ANSI/ASME N509, *Nuclear Power Plant Air-Cleaning Units and Components*. Additional requirements for HEPA filters are contained in Section 7.3.2, Air Filtration Systems, within these A&E Guidelines.

Other Ventilated Enclosures

Ventilated enclosures (other than fume hoods) used to control hazardous materials must be approved on a case-by-case basis by the EPA Safety and Sustainability Division and the EPA Real Property Services Division. Ventilated enclosures used for removal of heat or nuisance odors must comply with the parameters set forth in the ACGIH *Industrial Ventilation: A Manual of Recommended Practice for Design*. Additionally, other types of ventilated enclosures, such as glove boxes, biological safety cabinets and flammable liquid storage cabinets, shall meet NFPA and other code requirements.

7.3 Indoor Air Quality Requirements

7.3.1 Ventilation Rates

The outdoor air ventilation rates specified in ASHRAE Standard 62.1 are the minimum acceptable ventilation rates for EPA buildings. Instrumentation and controls shall be provided to assure outdoor air intake rates are maintained during occupied hours.

7.3.2 Air Filtration Systems

Air filtration shall be provided in every air handling system. Each AHU shall have a disposable pre-filter and a final filter. The filter media shall be rated in accordance with ASHRAE Standard 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. The pre-filters shall be MERV 8, and the final filters shall be MERV 13. Filter racks shall be designed to minimize the bypass of air around the filter media; the maximum allowable bypass leakage shall be 0.5 percent. Where occupancy requirements are likely to generate high levels of airborne particles, supplemental air filtration shall be provided on the return air duct entering the AHU, or dedicated and localized exhaust systems shall be utilized to contain airborne particulates. All filtration system designs must be approved by the EPA Real Property Services Division and the EPA Safety and Sustainability Division prior to construction.

HEPA Filtration

HEPA filters shall be used where required for specific laboratory functions. HEPA filters shall have an efficiency of 99.97 percent for particulates of 0.3 microns or greater, as determined by the dioctyl phthalate aerosol test; meet UL 586, *Standard for High-Efficiency, Particulate, Air Filter Units*; and satisfy ASHRAE Standard 52.2. It is recommended that a compensating damper be installed with a HEPA filter so that the airflow will remain constant over the life of the filter. It is good practice to install a pre-filter ahead of a HEPA filter to prolong the life of the HEPA filter. In general, bag-in/bag-out filter housings shall be used to minimize the spread of contaminants when the HEPA or pre-filter is changed. The resistance of HEPA filters to airflow, especially when airflow is loaded with contaminants, must be considered when designing the system. The pressure drop across HEPA and pre-filters shall be monitored and linked to an alarm indicating the need for filter change-out. HEPA filters may need fire protection; check with the EPA Project Manager for requirements.

7.3.3 Location of Air Intake(s)

The outside air intake(s) shall be located to provide the cleanest possible source of fresh air for the building. Air intakes shall not be located within or near the loading dock area or within the probable discharge areas for plumes of contaminated air from exhausts and vent stacks. Exhausts and vent stacks include, but are not limited to, fume hood exhausts, vehicle exhausts and exhausts from adjacent structures. Also avoid locations near potential microbial contamination sources, such as vegetation, organic matter, and bird and animal droppings.

Air intakes also shall comply with ASHRAE Standard 62.1; GSA PBS-P100; U.S. Department of Homeland Security ISC's policies, standards, and best practices; and the Department of Health and Human Services/CDC/National Institute for Occupational Safety and Health Publication 2002-139, *Guidance for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks*. However, protection from such attacks shall not be provided at the expense of introducing other potential contaminants (e.g., building exhausts) into the ventilation system.

7.4 Heating Systems

7.4.1 Energy Efficiency

In addition to meeting the energy efficiency requirements discussed in Section 7.1.1 within these A&E Guidelines, the Project A/E shall consider the following energy efficiency measures during design of the heating system, where technically feasible and life cycle cost-effective:

- **Cogeneration:** Consider the use of a cogeneration plant as a possible alternative in the planning of any large steam generation facility.
- **Heat Recovery:**
  - **Heat Recovery From Condensate:** Consider heat recovery from boiler condensate during boiler system design. Heat exchanger(s) may be utilized to remove heat from condensate not returned to the boiler. This recovered heat can be used to pre-heat domestic hot water, boiler make-up water, or low-temperature water returned to a boiler or heat exchanger.
  - **Flue Gas Heat Exchangers:** Consider use of flue gas heat exchangers in condensing or non-condensing boilers. Under all anticipated operating conditions, the stack temperature shall remain above the carbonic acid dew point to prevent flue damage.
  - Consider other heat recovery systems, where appropriate.
- **Ground Source Heat Pump:** See Section 7.4.4 within these A&E Guidelines.

7.4.2 Hot Water Distribution

Hot Water Piping

Pipes shall be marked in accordance with ANSI/ASME A13.1.

Pumps

Pumps shall be selected to ensure optimal operation at both part-load and full-load conditions. The number of primary hot water pumps shall correspond to the number of boilers, and a standby pump shall be provided for redundancy. The Project A/E shall perform LCCAs and use variable volume pumping systems where cost-effective.

7.4.3 Boilers

Standards

Heating equipment shall comply with the following standards, except where noted otherwise:

- **Oil-Fired Heaters:** NFPA 31, *Standard for the Installation of Oil-Burning Equipment*.
- **Gas-Fired Heaters:** NFPA 54, *National Fuel Gas Code*.
- **Liquefied Petroleum Gas-Fired Heaters:** NFPA 58, *Liquefied Petroleum Gas Code*.
- **Liquefied Natural Gas-Fired Heaters:** NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas*.

- **All Boilers:** NFPA 85, *Boiler and Combustion Systems Hazards Code*.

Boilers shall be sized per ASHRAE Standard 90.1.

Gas Trains

Boiler gas trains shall be installed in accordance with ASME CSD-1, *Controls and Safety Devices for Automatically Fired Boilers*.

Automatic Valve Actuators

Gas valve actuators shall not contain sodium/potassium elements, since these may pose a danger to maintenance personnel.

Venting

Products of combustion from fuel-fired appliances and equipment shall be vented outdoors from the building through breaching, vent, stack and/or chimney systems. Breaching connections from fuel-fired equipment to vents, stacks or chimneys shall be horizontal wherever possible and shall comply with NFPA 54. Vents, stacks and chimneys shall be vertical and shall comply with NFPA 54 and NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*. Breaching, vent, stack, and chimney systems may operate under negative, neutral, or positive pressure (depending on the application) and shall be designed based on (1) flue gas temperature and dew point; (2) length and configuration of the system; and (3) vent pipe insulation characteristics.

Venting materials shall be factory-fabricated and assembled in the field. The vents may either be double-wall or single-wall construction, depending on the distance from adjacent combustible or non-combustible materials. Material types, ratings and distances to adjacent building materials shall comply with NFPA 54 and NFPA 211.

Boiler Water Treatment

Boiler water treatment shall be provided to prevent deposits onto, or corrosion of, internal boiler surfaces, and to prevent the carryover of boiler water solids into the steam or hot water supply. Water quality measures for the heating plant and for other site process water users should be coordinated, and water conservation measures shall be implemented wherever feasible and life cycle cost-effective. These measures may include use of reclaimed water (e.g., collected rainwater) as feed water, recovery and use of condensate and blowdown water, or other measures.

The design of the boiler water treatment plant shall provide an automated chemical feed system and allow for daily sampling to determine internal water conditions. The plant shall contain adequate space and equipment for storing, handling and mixing treatment chemicals. Continuous versus intermittent blowdown operations shall be considered to determine which system will keep the concentration of total solids within acceptable limits. For continuous blowdown operations, the economics of installing a heat recovery system shall be considered. Blowdown rates and boiler water chemistry control shall be established in accordance with ASME *Consensus Operating Practices for Control of Feed Water/Boiler Water Chemistry in Modern Industrial Boilers*.

In accordance with OSHA regulations in 29 CFR 1910.151, *Medical Services and First Aid*, an emergency eyewash (shower type) must be provided in any work area(s) where treatment chemicals are being handled.

Boiler Plant Insulation

Consistent with OSHA Standard Interpretation “1998 - 08/19/1998 - Workers must be protected from hazards of heated (hot) surfaces” and OSHA Special Industries Standard 1910.261(k)(11), all hot surfaces “within 7 feet of the floor or working platform or within 15 inches measured horizontally from stairways, ramps, or fixed ladders shall be covered with an insulating material, or guarded in such a manner as to prevent contact.” Consistent with ASTM C1055 and industry standards, prevent contact with hot surfaces above:

- 140 °F, in areas where contact would be unintentional and unlikely.
- 120 °F, in areas where contact is likely or necessary for equipment operation.

Insulation shall conform with the manufacturer's recommendations and the *ASHRAE Handbook—Fundamentals*.

7.4.4 Ground Source (Geo-Exchange) Heat Pumps

If a ground source heat pump (GSHP) is included in the project design, the Project A/E must provide the following data for equipment associated with the GSHP system: design rated capacity, mechanical efficiency, noise ratings, motor speeds (including variable-speed drives where installed) and electrical characteristics.

Designer Qualifications

The GSHP designer shall have received and maintained an active credential through the Association of Energy Engineers' Certified GeoExchange Designer program. The designer shall provide three previous project references, documenting his or her systems have functioned in the intended manner for 12 months without significant repairs or failures.

7.5 Cooling Systems

7.5.1 Energy and Water Efficiency

In addition to meeting the energy efficiency requirements discussed in Section 7.1.1 within these A&E Guidelines, the Project A/E shall consider energy and water efficiency measures during design of the cooling system where technically feasible and life cycle cost-effective, including, but not limited to, the following:

- **Energy Recovery:** Consider energy recovery opportunities from chiller and refrigeration equipment.
- **Condensate Recovery:** Consider condensate recovery during AHU, chiller and cooling tower design. Condensate recovery circuits shall be plumbed and piped separately from any gray water, black water, recovered rainwater, and potable water systems and labeled accordingly. Recovered condensate shall be conveyed via gravity flow where possible. Additional flow capacity shall be provided for sprayed-coil systems. All drain pans and piping shall be insulated to eliminate or minimize sweating. If an outfall or connection to the sanitary sewer is provided, a deep-seal "U" trap must be installed to forestall any entry of sewer gas into the condensate collection system. A separate tank or process shall be inserted upstream from any storage/holding tank(s) to accommodate any necessary pre-treatment for bacterial contamination (e.g., chlorination, ozonation, other sterilization techniques). Depending on system operations, removal of oil and grease from bearings and/or wash-down chemicals from foaming sprays may also be required. This is typically accomplished using skimmers or coalescing separators.

7.5.2 Chilled Water Distribution Piping

Chilled water pipe shall be black carbon steel pipe or hard copper tubing. Standard wall steel pipe or Type L hard copper pipe will be satisfactory for most applications; however, the piping material selected shall be checked for design temperature and pressure ratings, as well as chemical compatibility with fluid/refrigerant, and shall meet Unified Facilities Guide Specifications 23 05 15, *Common Piping for HVAC*.

Pipes shall be marked in accordance with ANSI/ASME A13.1.

7.5.3 Chillers

The selection of centrifugal, reciprocating, helical, rotary-screw, absorption or steam-powered chillers shall be based on the coefficient of performance under full-load and part-load conditions.

Chiller Plant Sizing

Chiller plants shall be sized depending on the specific needs of the project. Where feasible, the EPA's preference is for multiple, modular units that provide maximum part-load efficiency/turn-down capacity in a life cycle cost-effective manner. Chiller plants shall also be designed to accommodate potential expansion of the facility's total load (i.e., by adding new, modular chillers).

During the design process, consideration shall be directed toward installation of modular chiller plants. For example, the modular approach can help designers match loads effectively using a rotary-screw compressor and a centrifugal compressor, instead of two centrifugal compressors. A reciprocating chiller could also be part of the energy-efficient module, combined with a screw compressor or a centrifugal compressor. In general, reciprocating chillers can serve the smallest loads efficiently, while rotary-screw chillers are the most flexible, and centrifugal chillers are most efficient when fully loaded. Typical kilowatt (kW) per ton profiles must be identified for the loads identified and temperatures required.

Consideration shall be given to using two chillers of unequal size, instead of two chillers of equal size, which allows more flexibility in matching loads. In this configuration, the smallest chiller can efficiently meet light loads (e.g., to keep process cooling equipment operating during the heating or temperate seasons). The additional chillers are staged to meet higher loads after the lead chiller—which may vary depending on the season—is operating close to full capacity. If an existing chiller operates frequently at part-load conditions, it may be cost-effective to replace it with multiple chillers staged to optimally match the demand profile of the facility.

Modular, packaged chillers can be especially useful in laboratory settings. A common problem in laboratory designs is the need to condition large volumes of incoming air to meet air change and exhaust requirements. Packaged chillers can assist in "balancing" the cooling load. Laboratory processes can be consolidated such that high cooling-load operations are concentrated in one area. Dedicated chiller(s) can then be installed to service this area, allowing the central heating plant chiller to be appropriately sized and precluding costly cooling energy from being "wasted" (as it would be if the central chiller[s] were over-sized).

7.5.4 Vapor Compression Chillers

Compression refrigeration machines shall be designed with safety controls, relief valves, and rupture disks, and in compliance with the procedures prescribed by ANSI/ASHRAE Standard 15.

Capacity Modulation

Centrifugal compressors shall be designed to operate with inlet control or variable-speed control for capacity modulation. Units shall be capable of modulating to 10 percent of design capacity without surge. Reciprocating compressors shall be designed for capacity control by cylinder unloading. Designs using hot-gas bypass control of compressors for capacity modulation shall not be used, except when capacity modulation is required at conditions below 10 percent of the rated load.

Motors

Compressor motors for refrigeration equipment shall be selected in compliance with all requirements of NFPA 70.

Refrigerants

Chiller design must comply with the CAA Amendments of 1990, Title VI: *Stratospheric Ozone Protection,* and 40 CFR 82, *Protection of Stratospheric Ozone*. New chillers shall use refrigerants identified by the EPA's SNAP program as alternatives to ozone-depleting substances and high global warming potential hydrofluorocarbons. Refer to EPA's SNAP program for the list of alternatives, available at 40 CFR 82, Subpart G, as well as http://www.epa.gov/snap. Chillers must be equipped with isolation valves, fittings and service apertures as appropriate for refrigerant recovery during servicing and repair, as required by Section 608 of the CAA Amendments.

7.5.5 Absorption Chillers

Minimum full- and part-load ratings for absorption chillers shall meet ASHRAE Standard 90.1.

7.5.6 Condensers

Water-cooled condensers shall comply with ANSI/ASHRAE Standard 15 and the ASME *Boiler & Pressure Vessel Code*, Section VIII. Water-cooled condenser shells and tubes shall have removable heads to facilitate tube cleaning. The use of marine water boxes on the condenser shall be considered for ease of tube cleaning.

All water-cooled condensers must be connected to a re-circulating heat rejecting loop. The heat rejection loop system shall be designed for a minimum 10 °F temperature differential and a minimum of 7 °F wet bulb approach between the outdoor air temperature and the temperature of the water leaving the heat rejection equipment. Heat tracing shall be provided for piping exposed to weather and for piping installed within 3 feet of the ground surface.

Air-cooled condensers shall meet the standard rating and testing requirements of ANSI/AHRI Standard 460, *Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers*, and ANSI/ASHRAE Standard 20, *Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers*. Air-cooled condenser intakes shall be located sufficiently distant from any obstructions that would restrict airflow. Air-cooled equipment shall be located away from noise-sensitive areas, and air-cooled condensers shall have refrigerant low-head pressure controls to maintain satisfactory operation during light loading.

7.5.7 Cooling Towers

Induced draft cooling towers with multiple-speed or variable-speed condenser fan controls shall be provided. Cooling tower acceptance and factory rating tests shall be conducted in accordance with Cooling Technology Institute ATC-105. The cooling towers shall have a clear distance equal to the height of the tower on the air intake side(s) to keep the air velocity low. Consideration shall be given to piping arrangement and strainer or filter placement such that accumulated solids are easily removed from the system. Clean-outs for sediment removal and flushing from basin and piping shall be provided.

Cooling towers shall be located to avoid problems with water drift (i.e., water vapor loss to the ambient air) and deposition of water treatment chemicals. Ensure cooling towers are equipped with drift eliminators to reduce any potential loss. Cooling towers shall have ample clearance from any obstructions that would restrict airflow, cause recirculation of discharge air or inhibit maintenance. The cooling tower's foundation, structural elements and connections shall be designed to meet local code/wind conditions, but with a minimum 100-miles-per-hour wind design load. Cooling tower basins and housing shall be constructed of stainless steel. If the cooling tower is located on the building structure, vibration and sound isolation must be provided wherever required. Noise greater than 80 dBa and/or transmission of resonant frequencies is prohibited. Cooling towers should also not be located in proximity to deciduous trees, wherever practicable.

Combustible casings are acceptable in cooling towers, provided that the fill and drift eliminators are non-combustible. (PVC and fire retardant-treated, fiberglass-reinforced plastic are classified as combustible.) In determining cooling tower requirements, the definitions of combustible and noncombustible in NFPA 214, *Standard on Water-Cooling Towers*, shall be used. Cooling towers with more than 2,000 ft^3 of combustible fill shall be provided with an automatic sprinkler system, designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 214, when any of the following conditions exist:

- The continued operation of the cooling tower is essential to the operations in the area it services.
- The building is totally sprinkler-protected.
- A fire in the cooling tower could cause structural damage or other severe fire exposure to the building.
- The value of the cooling tower is five or more times the cost of installing the sprinkler protection. The cost of the sprinkler protection shall include all factors involved, such as the sprinkler piping distribution system, the heat-sensing system, the control valve, and any special water supplies or extension of water supplies required.

Cooling towers with airstreams that pass through water shall have the water treated with an EPA-approved biocide to control etiological organisms, where necessary due to local conditions. In addition, processes to remove chlorinated hydrocarbon pesticides, herbicides, or other chemicals using fine filtration, activated carbon, or UV-catalyzed ozonation may be required depending on incoming concentrations. A maintenance program must be established to ensure continued, effective operation of these treatment systems.

Multiple cell towers and isolated basins are required to facilitate O&M and ensure redundancy. The number of cells shall match the number of chillers. Supply piping shall be connected to a manifold to allow for various combinations of online equipment. Multiple towers shall have equalization piping between cell basins. The equalization piping shall include isolation valves and automatic shutoff valves between each cell. Cooling towers shall have ladders and platforms for ease of inspections and replacement of packing and other components.

To prevent cavitation, variable-speed pumps that serve multiple cooling towers shall not operate below 30 percent of rated capacity. Cooling towers shall be elevated to maintain required net positive suction head on condenser water pumps and to provide a 4-foot (1.2-meter) minimum clear space beneath the bottom of the lowest structural member, piping or sump, to allow re-roofing beneath the tower.

Sub-Metering for Measurement and Verification

Cooling towers shall have flow meters that measure water input (cooling tower make-up water) and output water (blowdown). Cooling water blowdown is water that has traveled through the cooling tower structure and been cooled by convection and evaporation; it is not identical to boiler blowdown. Cooling towers shall have a conductivity meter installed to monitor water chemistry and automatically control cooling tower blowdown and water treatment chemical addition (where applicable). Additional information regarding the EPA's general metering requirements and requirements for flow metering is provided in Section 7.8, Energy and Water Metering, within these A&E Guidelines.

Overflow Alarm

The cooling tower basin shall be equipped with an overflow alarm to indicate when water from the cooling tower basin is overflowing to the sanitary sewer. Overflow drains are included in case the cooling tower make-up line has a stuck valve, resulting in continuous water flowing to the cooling tower basin. In many cases, this overflow can go undetected. The overflow alarm shall be connected to the BAS.

Water Efficiency

For conventional applications, cooling towers shall be designed to operate at a concentration ratio of 6 or greater (where feasible), in order to limit make-up water addition without simultaneously causing excessive scale buildup on the fill or in ancillary piping. A controller (e.g., solenoid switch) shall be connected to the blowdown control gate valve and be actuated by variations from the conductivity set point (i.e., an increase or decrease in the total dissolved solids in the bleed-off line resulting in an out-of-bounds conductivity measurement).

Depending on the application and project requirements, the following design features to enhance water use efficiency of cooling tower(s) shall also be considered:

- **Use of Variable-Speed Drives on Fan Motors:** Cooling towers may be good candidates for variable-speed drives because their motors are large, their fans often operate for long periods of time, and the applied heat loads can vary both seasonally and diurnally. High-efficiency motors on fans and efficient transmissions on geared fan drives shall always be specified.
- **Hybrid Cooling Towers:** Consisting of a "dry" or "air only" section above a "wet" or "water" section, this configuration promotes water efficiency by reducing drift and also aids in limiting visible plumes, which is useful for sites near residential areas or other areas where visibility is vital (e.g., airports, hospital or police helipads). The hybrid configuration also offers operational flexibility (e.g., the wet section alone can be operated during winter plumes when plume rise is less of a concern). Hybrid cooling towers shall be selected based on evaluation of both water efficiency and energy efficiency for the application and operating parameters, because these parameters are sometimes inversely related.
- **Side-Stream Treatment of Bleed-off Water Using Filtration or Lime Softening:** Filtration, using sand beds or paper media (for smaller units), can be beneficial in dusty and dry environments, where removal of hardness can preclude excessive scale formation; in both cases, the cooling tower will likely be able to operate at higher concentration ratios.

- **Automated Chemical Feed Systems:** Automated chemical feed systems shall be provided, unless demonstrated to not be life cycle cost-effective. Automated feed systems shall be calibrated to:
  - Increase or decrease the bleed-off volume based on specific conductivity readings (i.e., instantaneous total dissolved solids in the bleed water fraction).
  - Dose the treatment chemicals based on make-up water flow rates.

  These measures will optimize the instantaneous concentration ratio and also reduce labor and analytical testing costs. Special consideration shall be given to non-chemical water treatment methods, such as ultrasound, ozonation, electromagnetic pulse-power, filtration, ion exchange or impressed current. Selection of treatment methods (chemical or non-chemical) shall be dictated by site and project-specific factors, including wastewater discharge pollutant limits and fees, chemical handling and safety requirements, electric power availability and cost, available space and size of units or systems, etc.
- **Coupling With Other Onsite Processes:** Bleed-off water may be usable for other nonpotable applications, such as flushing toilets or as fire-fighting reserve water. Conversely, other excess water streams (e.g., recovered condensate, reject water from single-pass cooling of refrigeration systems) may be usable as make-up water for the cooling tower(s).

7.5.8 Data Center Cooling

Many layout and demand-side strategies can be utilized to reduce the overall demand data centers exert on the facility cooling plant. In particular, “hot aisle-cold aisle” configurations should be employed, to prevent mixing of exhaust air with fresh (cooler) air supplied by the ventilation system. Aisles must be wide enough for maintenance access and to conform with local fire/safety codes. Shrouds or ducting is sometimes necessary to create the desired airflow circulation patterns.

Airside economizers may aid in reducing cooling load on the central plant system (or packaged, dedicated chillers if used). Data centers with high cold-aisle temperatures (e.g., 78 °F or above) are more likely to benefit from operation of an airside economizer. Economizers integrated with the AHU(s) and controlled by the BAS are generally the preferred option, because they facilitate better control and require less direct oversight by facility managers.

7.5.9 Process Cooling

Laboratories

Laboratories often contain numerous critical processes and equipment that require cooling; examples include:

- X-ray equipment.
- Freezers for sample storage.
- Lasers.
- Analytical equipment, such as:
  - Gas chromatography/mass spectrometry (GC/MS).
  - Inductively-coupled plasma/mass spectrometry (ICP/MS).
  - Graphite furnace atomic absorption (GFAA).
  - Electrophoresis.

Laboratories often also require greater stability of temperature and/or pressure in chilled water loops. For example, maintaining precise temperature set points is critical to operation of sensing lasers in order to ensure repeatable measurements. In addition, analytical equipment depends on temperature stability as follows:

- Cooling of argon plasma torches for the ICP/MS and GFAA methods.

- Cooling of diffusion pumps associated with GC/MS equipment.

Pressure control/stability is essential where chilled water is circulated through glassware, especially where a positive displacement or turbine chilled water pump is used instead of a centrifugal pump.

Single-pass cooling is not permitted at EPA facilities. Application of small to moderate-sized, dedicated package chillers separate from the centralized space cooling/dehumidification loop is often a feasible and favorable strategy for laboratories. In addition to energy savings (and associated operating cost reductions), dedicated chillers often provide more stable control of temperature and/or pressure than central cooling networks. Where possible, process equipment requiring cooling shall be consolidated in a single space or adjacent spaces, to reduce the number of packaged process chillers required and/or minimize heat transfer and pressure drop losses in dedicated chilled water network(s).

7.6 Other Systems

7.6.1 Refrigeration/Cold Storage

Residential/light commercial-sized refrigerators (i.e., those used for storing food and drinks) shall comply with the applicable ENERGY STAR criteria. Laboratory refrigerators, freezers and walk-in coolers shall comply with AHRI Standard 420, *Performance Rating of Forced-circulation Free-delivery Unit Coolers for Refrigeration*, or ANSI/AHRI Standard 520, *Performance Rating of Positive Displacement Condensing Units*, as applicable. All refrigerators shall comply with ANSI/ASHRAE Standard 15.

Condensing units shall be fully- or semi-hermetic type, depending on the application and local environment. Condensing units and evaporators shall be factory-assembled and UL-listed. Evaporators shall be forced-air type. Air discharge shall be parallel to the walk-in ceiling.

Freezer evaporators shall have an automatic electric defrost system, including heater, time clock, fan delay control and heated drain pan. The defrost shall be time-initiated and temperature-terminated, with built-in fail-safe control. All systems shall include a pump-down cycle to provide additional protection against refrigerant surge.

Walk-in Environmental and Cold Storage Rooms

Walk-in environmental rooms are rooms in which temperature and/or relative humidity is controlled at a single set condition within specific tolerances, regardless of activity in the room. Walk-in environmental rooms shall be capable of maintaining a 4 °C (39.2 °F) room temperature, with a uniformity of 0.5 °C (0.9 °F) and a maximum gradient of 1 °C (1.8 °F), unless otherwise specified. A walk-in cold storage room shall be capable of maintaining a -20 °C (-4 °F) room temperature, with a uniformity of 2 °C (-3.6 °F) and a maximum gradient of 3 °C (-5.4 °F), unless otherwise specified.

Walk-in environmental and cold storage rooms shall feature temperature displays visible from a contiguous corridor, and shall be capable of producing a continuous reading of temperature (and transmitting these data to the BAS). Alarm systems with manual override capability shall be provided to advise room operators of fault conditions. Ventilation shall be provided if work is performed inside these rooms. Fume hoods are not permitted in environmental rooms. Doors shall be provided with a locking mechanism capable of release at all times from the room interior, whether or not the door is locked.

Walk-in environmental and cold storage rooms shall include shelving. Walk-in coolers are considered enclosed spaces and require automatic fire sprinkler protection inside them. Refer to Chapter 10, Fire Protection, within these A&E Guidelines for additional information. Walk-in cold storage rooms shall have oxygen sensors and alarms to ensure that oxygen is not being displaced.

A separate refrigeration system shall be provided for walk-in cold storage and environmental rooms. If refrigeration is provided by the building's primary chiller water system, a backup, self-contained system must be provided.

Where necessary, cold storage rooms shall have systems to prevent formation and buildup of ice on walking surfaces.

7.7 Plumbing and Piping

7.7.1 Water Supply Systems

General Requirements

The criteria in this section apply to plumbing systems (e.g., fixtures; supply, drain, waste, and vent piping; the service water heating system; safety devices; appurtenances) inside the building and up to 5 feet beyond the building exterior wall. Plumbing shall comply with the International Plumbing Code (IPC) or local plumbing code and the *ASHRAE Handbook*. Access panels and cleanouts shall be provided where maintenance or replacement of equipment, valves or other devices is necessary. Pipes shall be marked in accordance with ASME A13.1 (including color coding) and shall conform with requirements of GSA PBS-P100 and NFPA 45, as applicable.

Potable Water Supply Network

Type K copper tubing shall be used for below-grade supply piping. Type L copper tubing shall be used for above-grade supply piping. The laboratory potable water supply shall be piped in Type K or Type L copper. For new systems, domestic water shall be supplied by a separate service line and not by a combined fire protection and potable water service or a combined process water and potable water system.

Fittings for Type K tubing shall be flared brass, solder-type bronze or wrought copper. Fittings for Type L tubing shall be solder-type bronze or wrought copper. Fittings for plastic pipe and tubing shall be solvent-cemented or Schedule 80 threaded connections. No lead solder shall be used for copper pipe in potable water systems. Dielectric connections shall be made between ferrous and non-ferrous metallic pipe.

Stop valves shall be provided at each fixture. Accessible shutoff valves shall be provided at branches serving floors, fixture batteries for isolation or at risers serving multiple floors. Shutoff valves also shall be provided to isolate equipment, valves and appurtenances for ease of maintenance. Accessible drain valves shall be provided to drain the entire system. Manual air vents shall be provided at high points in the system. Manufactured water hammer arresters shall be provided and shall be installed in appropriate locations.

Provision for expansion shall be made where thermal expansion and contraction may cause piping systems to move. This movement shall be accommodated by using the inherent flexibility of the piping system as designed, loops, manufactured expansion joints and couplings.

Where domestic water or fire protection service lines enter buildings, suitable flexibility shall be provided to protect against differential settlement or seismic activity, in accordance with the IPC and NFPA 13, respectively.

Lead-in-Potable Water

Potable water systems components, such as piping, valves, fittings, water coolers and fixtures, shall conform with requirements of the EPA National Primary Drinking Water Regulations (NPDWR) for lead and copper (40 CFR Parts 141 and 143). Components shall not be incorporated unless bearing the NSF/ANSI Standard 61 mark, indicating that the product complies with the health effects requirements of NSF/ANSI Standard 61 for materials designed for contact with potable water.

Upon substantial completion of the building, the potable water system within the building, as well as the potable water supply main, shall be tested for lead and copper content in accordance with EPA 816-B-05-008, *3Ts for Reducing Lead in Drinking Water in Schools—Revised Technical Guidance*. Testing of the building's potable water system and the potable water supply main shall be coordinated with the local water company, county health department and the state environmental protection agency, as applicable.

Sterilization

New water supply systems or existing supply systems that have undergone rehabilitation will require sterilization in accordance with American Water Works Association (AWWA) C651, AWWA C652, applicable provisions of the IPC, and applicable state and local plumbing codes.

Drain, Waste and Vent Lines

Underground lines that do not service laboratory areas shall be service weight, cast iron, soil pipe, hub-type (with gasket). Hub-less, cast iron, soil pipe may be used in locations where piping is accessible. Above-grade lines that are 12 inches in diameter and larger shall be either hub-less or hub-type (with gasket), service weight, cast iron pipe. Lines less than 12 inches in diameter may be ABS pipe where allowed by the project criteria. Pipe and fittings shall be joined by solvent cement or elastomeric seals. Cast iron soil pipe fittings and connections shall comply with Cast Iron Soil Pipe Institute guidelines. Provisions for expansion shall be included, as above.

Underground lines servicing laboratory areas shall be acid-resistant sewer pipe, conforming with one of the following, as applicable: ASTM D1785, ASTM D2241, ASTM D2447, ASTM D4101, ASTM F1412 or ASTM F2389.

Socket-type polyethylene fittings may be used for outside diameter-controlled polyethylene pipe. Pipe shall be welded together following ANSI/American Welding Society (AWS) D1.1/D1.1M, ASTM D2241 and ASTM D2855.

Trap Seal Protection

Where there is the possibility of loss of the seal in floor/funnel drain traps, a trap primer valve and a floor/funnel drain with trap primer valve discharge connections shall be installed.

Backflow Preventers

Backflow preventers of the reduced-pressure zone type shall be provided on all domestic water and fire protection lines serving the building.

Safety Devices

Tempering valves shall be of the fail-safe, pressure-balance type. Hot water generation equipment shall be provided with ASME code-stamped tanks; when of sufficient capacity, water temperature or hot water input rate shall follow applicable provisions of the ASME *Boiler & Pressure Vessel Code*. Approved pressure-relief devices, such as combination temperature-pressure or separate units, shall be provided. Backflow preventers and air gaps shall be used to prevent cross-connection (contamination) of potable water supplies. Vacuum breakers (to prevent back-siphonage) shall be used only in conjunction with administrative controls.

Pressure-Reducing Values

Pressure-reducing valves shall be provided where service pressure at fixtures or devices exceeds the normal operating range recommended by the manufacturer. Wherever failure of a pressure-reducing valve could cause equipment damage or unsafe conditions, a pressure-relief valve shall be provided downstream from the reducing valve.

Water Hammer Arrestors

Water hammer arrestors shall be provided in the following locations:

- At each elevation change of every horizontal branch to fixture batteries.
- At all quick-closing automatic valves (e.g., mechanical make-up supplies, water coolers, flush valves, single-lever control faucets, temperature regulating valves, dishwashers, return pumps).
- Each floor on each horizontal main for branches with and without individual fixture or battery water hammer arrestors, for both hot and cold water.

Water hammer arrestors shall comply with the Plumbing and Drainage Institute Standard PDI-WH201, *Water Hammer Arrestors,* ANSI/ASME A112.26.1M, or as required by code, and as recommended/required by the fixture/equipment manufacturer.

De-ionized Water System

Unless otherwise specified in the project criteria, the central de-ionized water system shall have a resistivity of greater than 10 megaohms (MΩ) at the tap in each laboratory. This system may be a centralized system or several decentralized systems, depending on the requirements of the specific laboratory facility. Water quality shall conform to ASTM Type I requirements for reagent-quality water and to American Pharmaceutical Association requirements for water used in microbiological testing. Type I water is typically prepared by reverse osmosis, then polishing it with mixed-bed de-ionizers (i.e., ion exchange process) and passing it through a 0.2 micron (µm) membrane filter.

A realistic needs analysis shall be performed prior to sizing the de-ionized water system. Sizing the system to provide water simultaneously to all purified water taps is very likely to result in a highly oversized system, resulting in increased energy and water waste. In addition, all centralized purified water systems should recover at least 75 percent of the feed water as permeate.

Pipes and fittings for the de-ionized water system shall be polyvinylidene fluoride Schedule 80 or unpigmented polypropylene. A bypass or drain legs shall be provided at the lowest points in the piping system to avoid stagnation of water at the branch pipes during extended periods of non-use.

Hot and Cold Water, Nonpotable

The laboratory nonpotable water supply shall be piped in Type K or Type L copper. Approved backflow prevention devices shall isolate the laboratory nonpotable water system from the potable water system. The hot water supply runs shall be insulated, and hot water shall be recirculated to conserve energy where feasible.

Culture Water System

Culture water system piping shall be constructed of Schedule 80 unpigmented polypropylene and shall have no metal in contact with the water. The holding tank shall be lined with unpigmented polypropylene. Transfer pumps shall be of solid unpigmented polypropylene. Water shall be provided to each culture tank in constant overflow mode to keep the tanks aerated and carry away waste products.

7.7.2 Service Hot Water

Domestic hot water supplies shall be generated and stored at a minimum of 140 °F, and tempered to deliver 124 °F water to outlets or in accordance with IPC. Hand washing, lavatory, sink, and similar fixtures accessible to the disabled, elderly, or children shall be tempered to deliver 85 °F to 109 °F water temperatures at the fixture or group of fixtures. Bathing and showering fixtures (except emergency showering) shall be tempered to deliver 85 °F to 120 °F water temperatures at the fixture or group of fixtures.

Individual fixture thermostatic mixing valves shall be provided where distributed outlet temperatures may exceed 124 °F. Hot water supply to dishwashers shall be at 140 °F, and the temperature shall be boosted from 140 °F to 180 °F for the final sanitizing rinse. Heat pump-powered hot water heaters shall be used where energy cost savings will result.

Solar Domestic Hot Water Heating

Solar energy systems used for domestic hot water heating shall be installed if life cycle cost-effective. Temperature-actuated tempering valves shall be installed to ensure that scalding hot water is not delivered to individual fixtures.

7.7.3 Water Fixtures and Fittings

In accordance with the *Guiding Principles for Sustainable Federal Buildings*, the design shall meet requirements in ASHRAE Standard 189.1 Sections 6.3.2 (Building Water Use Reduction-Mandatory Provisions), 6.4.2 (Building Water Use Reduction-Prescriptive Option), and 6.4.3 (Special Water Features-Prescriptive Option), except where more stringent standards are identified below.

High-Efficiency Urinals

WaterSense labeled high efficiency urinals that operate at 0.125 gallons per flush or less shall be used.

Waterless urinals shall comply with applicable provisions of ANSI Z124.9, ASME A112.19.19 and the IPC. Liquid refills and traps shall have minimum lives of 1,500 uses and 7,000 to 10,000 uses, respectively.

Lavatory Faucets

Lavatory faucets shall be lever-operated, push-type or electronically activated for one-hand operation without the need for tight pinching or grasping. Drain pipes and hot-water pipes under a lavatory must be covered, insulated and/or recessed far enough such that wheelchair-bound individuals who are without sensation will not burn themselves.

Metered-valve faucets deliver a preset amount of water and then shut off. To control water usage, the preset amount of water can be reduced by adjusting the flow valve. ABAAS requires a 10-second minimum on-cycle time.

Laboratory Service Fittings

Laboratory service fittings for each laboratory space are specified in the room data sheets and shall be compatible with their intended use. All service valves, fittings and accessories shall be fabricated from cast brass with a minimum copper content of 85 percent, except for items that are to be brass-forged or bar stock. All service valves, fittings and accessories shall be especially designed for laboratory use. All laboratory service fittings shall have an acid-resisting and solvent-resisting clear plastic coating applied over a clean, polished, chrome-plated surface. Service fittings at fume hoods shall have an acid-resistant and solvent-resistant plastic coating applied over a fine sandblasted surface.

Faucets in laboratory workspaces shall have flow no less than 2.0 gallons per minute (gpm) and no greater than 5.0 gpm, unless otherwise dictated by project requirements.

Glassware Washing Sinks

Sinks dedicated to the purpose of washing laboratory glassware shall have a high or telescoping spigot with a swing-type gooseneck to accommodate large pieces of glassware. Large sinks shall be provided with a hand-held sprayer whose weight is supported for ease of operation. All glassware washing sinks shall be ventilated at a rate of 280 cfm to 300 cfm, with an exhaust air duct connection at the top of the sink below the bench top.

Showers

Shower stalls shall be of fiberglass construction, complete with door, soap ledge, showerhead, separate hot- and cold-water knobs, non-skid floor finish, and standard 2-inch floor drain. Shower stalls shall also provide a small change area with lockers. Shower stalls shall conform with applicable requirements of ABAAS.

Showerheads shall be WaterSense labeled and have a maximum water flow rate less than or equal to 1.75 gpm.

In addition, the showerhead or associated systems shall mix hot and cold water adequately to prevent scalding, which generally occurs at a water temperature greater than 110 °F (or lower for sensitive populations such as children and elderly persons).

Flow restrictors are washer-like disks that fit inside showerheads and were initially well-accepted due to their simplicity and low cost. However, facility operators have discovered that flow restrictors provide poor water pressure in most showerheads; hence, they shall not be used on EPA new construction and major renovation projects.

Water Coolers

Self-contained, mechanically refrigerated coolers shall be provided wherever a need for drinking fountains exists. Ratings shall be based on ANSI/ASHRAE Standard 18, *Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration*. Electrical equipment shall be UL-listed. The refrigeration coils shall not be assembled using lead solder, and all components must bear the NSF/ANSI Standard 61 mark, indicating the components are free of lead. The refrigeration system shall be hermetically sealed and use refrigerants that are not ozone-depleting and do not have a high global warming potential.

All water coolers and locations for water coolers shall comply with applicable ABAAS provisions.

The water cooler shall include a bottle filling station to fill glasses or other beverage containers.

Janitor Closet Sinks

Janitor closets for cleaning equipment, materials and supplies shall be provided on all floors. All janitor closets shall be equipped with a service sink with hot and cold water taps. Containment drains shall be plumbed for appropriate disposal of liquid wastes in spaces where water and chemical concentrate mixing occurs for maintenance purposes. Permanent signage shall be affixed, indicating prohibited items for disposal (based on presence/absence and type of onsite wastewater treatment and local sewer permit prohibitions and concentration limits).

7.7.4 Stormwater Drainage System

A complete stormwater building drainage system shall be provided for all stormwater drainage for roofs, plazas, balconies, decks, window wells, parking structures, parking garages and similar. (Note that this does not include stormwater managed by means of low impact development strategies). Clear water drainage (e.g., cooling coil condensate drainage, evaporation pan drainage, ice makers) and similar clear, non-chemically treated drainage shall discharge to the stormwater drainage system and not to the sanitary drainage system. In addition, unless granted an exemption by the EPA Project Manager, all projects shall consider the efficacy of disconnecting some or all drains from the storm drainage or sewer system, thus returning a portion or all of the total drainage for infiltration or for onsite beneficial uses.

All projects shall comply with the EPA *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*—in particular, the instructions regarding maintaining the pre-development volume, rate, temperature and duration of stormwater runoff at the site after the project is completed.

Stormwater Drainage Pipe and Fittings

The stormwater and associated vent system shall be designed in compliance with applicable local codes and standards. P-traps and house-traps shall only be provided on storm systems where required by code or by state or local authorities. Piping shall be service-weight, cast iron soil pipe with hub and spigot fittings and joints with elastomeric gaskets (by pipe manufacturer). Above-ground piping shall have hub-less fittings and joints (by pipe manufacturer), within 12 inches of each side of every joint where not superseded by code.

Stormwater Vent Piping and Fittings

Storm vent piping, where required for P-traps, sumps, interceptors and separators, shall be service-weight, cast iron soil pipe with hub and spigot fittings and joints with elastomeric gaskets (by pipe manufacturer). Above-ground piping shall have hub-less fittings and joints (by pipe manufacturer). Where approved, Type K drain, waste, or vent (DWV) copper piping with 95 percent tin/5 percent antimony solder joints may be used.

The EPA's Comprehensive Procurement Guidelines include minimum recycled content requirements for non-pressure pipe (i.e., pipe that can be utilized for drainage applications).

Storm Drains

Roof drains and planter drains in non-pedestrian/vehicle areas shall have high dome strainers. Receptors, hub drains, trench drains and similar drains shall have dome-bottom strainers (in addition to pedestrian/vehicle grate strainers where required) to reduce splashing, increase free area and prevent blockage by debris.

Stormwater Equipment

Drains in parking structures and garages shall discharge to an oil/water/sediment separator prior to discharge to the storm sewer when required by code, state or local authority. The drain body and frame-and-grate strainers shall be rated for expected traffic loadings (including dynamic loads) and shall include drain adapters, extensions, receivers, deck clamps, gravel stops and similar appurtenances, as required by the design and by local codes. The drain strainer free area shall be equal to or greater than the free cross-sectional area of the calculated outlet pipe.

Drain strainers in pedestrian areas shall be heel-proof type. To prevent access by rodents, every drain and system opening shall have 0.25-inch or smaller strainer openings and discharges shall be elastomeric pinch valves or similar.

In general, drains shall be cast iron body-type with nickel-bronze strainers for finished pedestrian areas, aluminum domes for roof drains, and ductile iron or bronze finish for unfinished pedestrian areas. Rainwater drains and equipment room areas shall be equipped with large diameter strainers. Ramps shall be equipped with either trench drains or roadway inlets to manage drainage. Trap primers shall be provided for P-traps (where P-traps are required by code, state or local authority).

Sump Pumps

Sump pumps shall only be used where gravity drainage is not possible. Only rainwater, storm and clear water drainage from the lowest floors of the building shall be connected to the sump pump; drainage from upper floors shall use gravity flow to the public sewer. Sump pumps shall be alternating duplex pumps and shall be connected to the building's backup power system.

7.7.5 Sanitary Wastewater System

Sanitary Pipe and Fittings

A complete sanitary building drainage system shall be provided to service all plumbing fixtures, sanitary floor drains, kitchen equipment, and other equipment with sanitary, soil, or waste drainage/discharge.

The sanitary waste and vent system shall be designed in compliance with applicable codes and standards. Piping shall be service-weight, cast iron soil pipe with hub and spigot fittings and joints with elastomeric gasket (by pipe manufacturer). Aboveground piping shall have hub-less fittings and joints (by pipe manufacturer), with pipe supports that comply with code (generally within 12 inches of each side of each joint).

Vent Piping and Fittings

Piping shall be service-weight, cast iron soil pipe with hub-and-spigot fittings and joints with elastomeric gaskets (by pipe manufacturer). Aboveground piping shall have hub-less fittings and joints (by pipe manufacturer), or else consist of Type K DWV copper with 95 percent tin/5 percent antimony solder joints.

Sanitary Floor Drains

Sanitary floor drains shall be provided in multi-toilet fixture restrooms, kitchen areas, mechanical equipment rooms and locations where interior floor drainage accumulates sanitary-type wastes. Single-fixture toilet rooms do not require floor drains. In general, floor drains shall be cast iron body type with 6-inch diameter nickel-bronze strainers for public toilets, kitchen areas and other public areas. Receptor drain outlets shall be at least two times the area of combined inlet pipe areas. Floor drains in equipment room areas shall be equipped with large diameter cast iron strainers, and parking garages shall require large diameter tractor grates rated for expected wheel loading. Trap primers shall be provided for all sanitary drains (e.g., floor drains, receptors, open site drains, hub drains) where drainage is not routinely expected or is seasonal.

The facility system shall be plumbed such that only sanitary wastewater is managed through the sanitary sewer system. The system shall have no connections with floor drains or drain piping that is used for the collection of industrial wastewaters containing Clean Water Act Priority Pollutants or wastewaters that meet the definition of a RCRA hazardous waste. Grease interceptors shall be provided for all drains and fixtures that receive fats, oils, or grease-containing waste that are within 10 feet of the cooking battery and/or mop and service sinks in kitchen areas, or where required by the state health department and local authorities.

All grease interceptors shall be connected to the sanitary sewer system. Grease interceptors shall be sized in compliance with the requirements of the local sewer authority and with Plumbing and Drainage Institute Standard PDI-G101. Generally, food grinders, vegetable cleaning sinks, fish-scaling sinks, meat-cutting sinks and clear water wastes are prohibited by the local authority from extending to the grease interceptor. An individual solids separator must be provided for fish-scaling sinks.

Oil/Water/Sediment Separator

Floor drains and/or trench drains in vehicle repair garages shall discharge to an oil/water/sediment separator prior to discharge to the sanitary sewer. The most common configuration will consist of a triple basin system with or without a downstream laminar-flow, parallel plate coalescing separator for moderate to heavy oil loadings. Depending on the wastewater stream composition, additional treatment processes such as a vortex-type settling vessel,[6] activated carbon beds or skimmers may also be required prior to discharge. Discharge limits will be specified in the applicable sewer authority pre-treatment permit. Refer to the EPA Environmental Management Manual for additional environmental performance and compliance information.

Automatic Sewage Ejectors

Automatic sewage ejectors shall only be used where gravity drainage is not possible. Only sanitary drainage from the lowest floors of the building shall be connected to the sewage ejector; fixtures on upper floors shall use gravity flow to the public sewer. Sewage ejectors shall be non-clog, screen-less, alternating duplex pumps, capable of passing a 2-inch solid, with each discharge not less than 4 inches in diameter. They shall be connected to the building backup power system.

Clear Water and Non-Clear Water Drainage

Storm rainwater, cooling coil condensate drainage and similar clear-water drainage shall not discharge to the sanitary drainage system. Chemically treated mechanical discharge from cooling towers, boilers, chillers and other mechanical equipment shall discharge to the sanitary sewer system. Purified steam (i.e., from humidification processes) shall not be discharged to the sanitary sewer system.

7.7.6 Process Wastewater System

Process wastewater collection and treatment will depend on the specific facility's operations and discharge permit requirements. In general, EPA facilities that generate process wastewater streams will be laboratories. Discharge from shop area floor drains shall be, at a minimum, conveyed through an oil/water/sediment separator as outlined above. In certain cases (e.g., where solvents are used or the facility is located in a watershed with strict discharge limits), additional treatment such as chemical precipitation or activated carbon adsorption may be required to meet discharge limits.

Process wastewater treatment systems shall be designed to achieve compliance with the required discharge standards in (1) 40 CFR 403 or applicable local and state regulations and ordinances (for pre-treatment discharges to POTWs); and (2) 40 CFR Parts 405-471 (for direct discharges to waters of the United States).

All non-sanitary laboratory wastewaters are required to pass through an onsite water treatment system to control pH, as well as other chemical and/or material constituents, before discharging to a municipal sewer system and local POTW. The system shall be designed and constructed in accordance with 40 CFR 403.5, the National Pollutant Discharge Elimination System, and the local POTW requirements (i.e., sewer connection permits and/or pre-treatment discharge authorizations). Refer to Section 7.9.4, Process Wastewater, within these A&E Guidelines for information about required monitoring and measuring of process wastewater characteristics.

System components, in particular the outfall to the sewer system, must be accessible for monitoring, sampling and maintenance. In addition, the system shall be provided with emergency power and an audible and visual alarm to alert staff in event of non-conforming discharges.

Design of the onsite wastewater collection and pre-treatment system should consider alternatives for reuse, recycling or other beneficial use of non-toxic wastewater streams (or waste streams that the POTW cannot accept in its system). As one example, an onsite wetland might be used where feasible to remove heavy metals from wastewater while also storing and filtering stormwater runoff.

7.7.7 Natural Gas Supply

Gas distribution piping shall comply with local codes and requirements. Fuel gas systems shall comply with NFPA 54. Liquefied petroleum gas systems shall comply with NFPA 58.

6 For example, the vortex and oil baffle system installed to process stormwater drainage at the EPA's New England Regional Laboratory in Chelmsford, Massachusetts.

Service Entrance

Natural gas service utility piping entering the building shall be protected from accidental damage by vehicles, foundation settlement or vibration. Wall penetrations shall be above grade and provided with a self-tightening swing joint located upstream of the building and wall penetration.

Where wall penetration above grade is not possible, the gas pipe shall be encased in a Schedule 80 black steel, corrosion-protected, sealed and vented, gas pipe sleeve that extends from 10 feet upstream of the building wall penetration exterior (or excavation shoring limits if greater) to 12 inches (minimum) downstream of the building wall penetration. Gas piping shall not be placed in unventilated spaces, such as trenches or unventilated shafts, where leaking gas could accumulate and result in an explosion.

Gas piping shall not be run in any space between a structural member and its fireproofing. Pipelines shall be labeled in accordance with 29 CFR 1910.1200. Local gas utility and code requirements shall be followed.

Gas Meter Regulators

To avoid placing any strain on the gas piping, any meters, regulators or similar attachments shall be adequately supported. Any vents or rupture discs on the equipment shall be vented to the exterior of the building.

Shutoff Valves

Earthquake-sensitive shutoff valves shall be provided for each gas entry, where required by local code.

Gas Piping within Building Spaces

Gas shall not be piped through confined spaces, such as trenches or unventilated shafts. All spaces containing gas-fired equipment, such as boilers, chillers, water heaters and generators, shall be mechanically ventilated and include automated methane detectors and alarms connected to the BAS. Vertical shafts carrying gas piping shall be ventilated. Gas meters shall be located in a ventilated gas meter room, thus avoiding leakage concerns and providing direct access to the local gas utility. All gas piping inside ceiling spaces shall have plenum-rated fittings, and no gas valves (whether concealed or accessible) shall be installed above ceilings. All diaphragms and regulators in gas piping must be vented to the outdoors.

Requirements concerning natural gas supply and distribution systems for laboratories are contained in Section 7.7.9, Laboratory Gas Storage and Distribution Systems, within these A&E Guidelines.

7.7.8 Fuel Oil Storage and Supply

Where liquid fuel is used, provide a UL-listed, double-wall containment type storage tank. Use aboveground fuel oil storage tanks (ASTs) rather than underground fuel oil storage tanks (USTs), where possible. For facilities that are required to develop a Spill Prevention, Control and Countermeasure Plan per 40 CFR 112, the requirements of that plan will govern.

For specific requirements regarding fuel storage, refer to:

- NFPA 30, *Flammable and Combustible Liquids Code*.
- EPA Environmental Management Manual.

Fuel Oil Piping Systems

Fuel oil piping systems shall be double-walled containment pipe (pipe-in-pipe) when indoors, outdoors, or buried, and shall be Schedule 40 black steel or black iron piping. Fittings shall be of the same metal or alloy as the pipe material. Valves shall be bronze, steel, or iron and shall be screwed, welded, flanged, or grooved. Duplex fuel oil pumps with basket strainers and exterior enclosures shall be used for pumping fuel oil to fuel-burning equipment.

Underground Fuel Oil Storage Tanks

USTs shall be of double-walled, non-metallic construction (e.g., fiberglass), or contained in lined vaults.

A monitored and alarmed liquid and vapor leak detection system shall be provided in the interstitial space between the two tank walls. Vaults shall be equipped with monitoring wells and/or sumps. Each UST system shall also have an automatic leak detection probe that continuously measures the liquid level—and hence volume—of product in the tank and provides a local visual or printed readout, as well as a data signal to the BAS. Each UST shall be equipped with a spill catch basin and an overfill sensor that triggers a visual/audible alarm, consistent with 40 CFR 280.

In colder climate regions, a fuel oil day tank shall be installed per the International Mechanical Code.

Aboveground Fuel Oil Storage Tanks

In accordance with the secondary containment requirements in 40 CFR 112 and NFPA 30, all ASTs shall be double-walled and equipped with an interstitial sensor similar to USTs. ASTs shall be equipped with overfill alarms similar to USTs.

7.7.9 Laboratory Gas Storage and Distribution Systems

Systems for flammable and non-flammable gas storage and distribution must meet the following requirements.

General Requirements

Special gas services for flammable and non-flammable gases shall be provided to all laboratories requiring their use. Gases shall be stored and piped in accordance with the following standards:

- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*.
- NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*.
- NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.
- NFPA 54, *National Fuel Gas Code*.
- NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

In situations not covered by NFPA code, the Compressed Gas Association shall be consulted for guidance. No piping from any of these systems shall be run above or in the exit access corridors.

Gas cylinders for non-flammable gases, both in-use and standby, shall be manifolded and distributed from an area that is located as far as possible from frequently used and occupied areas of the building, as well as accessible from either the central storage area or directly from the loading and receiving dock area.

This space shall be designed and ventilated in accordance with applicable code requirements.

Flammable gas cylinders shall be exposed at the point of use only and shall otherwise be housed in approved cabinet enclosures that are mechanically ventilated to the atmosphere and equipped with leak detection monitoring devices and visible/audible alarms.

Before acceptance, all gas distribution systems must be pressure-tested for tightness and purged. The required level of purity specified at the point of use shall be maintained at all points in the system during testing and purging.

Distribution Systems

For all laboratories except metals analysis laboratories, a seamless copper piping gas distribution system for non-flammable gases shall be provided to all designated laboratory workspaces. Ideally, the length of the gas distribution lines should not exceed 100 feet to avoid the necessity for pipe joints. If pipe joints are required due to line length, prior approval by the EPA Project Manager is required. Regulator valves, pipe sleeves and other auxiliary equipment required to furnish gas at the required pressures shall be provided.

Pipe sizes shall be selected to ensure that the pressure delivered at the point of use (i.e., after line and fitting losses) is adequate for the application. The number and type of gas outlets in each room will be indicated on the room data sheets. Exact and final outlet locations in each laboratory must be approved by the EPA Project Manager during the design phase. The system design shall include a capability for individual room cut-off.

Distribution Systems for Metals Laboratories

For all laboratories used for metals analysis, a double-walled piping system, consisting of seamless Teflon® piping inside a larger-diameter PVC containment pipe, shall be installed. For the inner pipe, alternatives to Teflon construction may be utilized if approved by the EPA Project Manager. Pipe sizes shall be selected to ensure that the pressure delivered at the point of use (i.e., after line and fitting losses) is adequate for the application.

Bottle Gas Supply

The bottle gas supply shall be provided with duty and standby sets with automatic change-over valves and controls. For all gases, an indicator panel shall be installed close to the point of use in each of the laboratories. The distance between the point of use and the panel shall not exceed 75 feet.

When toxic or explosive gases and/or simple asphyxiants are used in a confined space, a multi-point gas analyzer and alarm system shall be provided to monitor concentration of the gases within this space. This system shall consist of gas sensors/transmitters, wiring, and a microprocessor-based monitoring-and-alarm control panel linked with the BAS. The number and type of sensors and transmitters shall depend on the specific application.

Each sensor/transmitter shall transmit a frequency signal proportional to the gas concentration and shall have a special amplifier to eliminate the effects of radio frequency interferences. The control panel shall be capable of monitoring and providing an alarm on different types of gases in different zones and shall have an audible and a visible alarm. The control panel shall also have a factory-wired terminal strip to interface with the BAS for remote monitoring and alarms.

Liquid Nitrogen and Liquid Argon

Liquid nitrogen and liquid argon must be delivered to the point of use in liquid form. Insulation in the delivery system must be sufficient to prevent evaporation losses of liquid nitrogen. The gas distribution room for these two gases shall be as close as possible to the laboratory rooms where the gases are used, preferably adjacent to them. This inert gas distribution room shall also be directly accessible from the outside of the building without use of the laboratory corridors. One large tank for each gas shall be provided; each tank shall be permanently fixed in the room. The tanks shall be outfitted with necessary valves and controls, as required by the gas supplier.

The Project A/E shall determine whether an oxygen meter should be installed in confined areas or small areas where liquid nitrogen and/or argon are stored, distributed or transferred. An example of a calculation tool can be found at http://www.oxigraf.com/technical_support.html. The Project A/E shall assume that 100 percent of the liquid nitrogen or liquid argon is released into the space.

Natural Gas Distribution System

Unless otherwise specified in the project criteria, each laboratory facility must have a natural gas distribution system. Refer to Section 7.7.7, Natural Gas Supply, within these A&E Guidelines for natural gas distribution system requirements.

Compressed Air Systems

Where compressed air systems are required, these systems shall be provided with oil and water traps, a dryer, and all necessary controls and appurtenances. Unless otherwise specified in the project criteria, each compressed air system shall have duplex compressors (i.e., one redundant compressor), with an automatic lead/lag switch and a single compressed air tank. Compressed air systems for processes shall be completely independent of any existing pneumatic systems for HVAC controls.

The compressed air system shall include a water trap and pressure regulator(s) at each laboratory room or area. An audible alarm and remote annunciation shall be provided to alert personnel to a loss of air pressure. Air compressors shall be equipped with vibration pads and springs as required to diminish vibration and sound generated by compressors. In addition, compressor locations should be selected so as to minimize transmission of vibration and sound to the building or rooms that the compressors service.

Vacuum Systems

Where a laboratory vacuum system is required, it shall consist of several vacuum pumps capable of evacuating air at a regulated suction of 25 inches of mercury or as specified in the project criteria. Unless otherwise specified in the project criteria, each vacuum system shall have duplex pumps, an automatic lead/lag switch and a single tank. An audible alarm and remote annunciator shall be provided to alert personnel to a loss of vacuum.

Vacuum pumps shall be air-cooled, dry vacuum pumps. Vacuum pumps shall also be equipped with vibration pads and springs as required to substantially reduce vibration and sound generated by the pumps. Furthermore, the pump location should be selected so as to minimize transmission of vibration and sound to the building or rooms that the pumps services.

7.7.10 Emergency Eyewash Units and Safety Showers

Emergency Eyewash Units

Emergency eyewash units or combination eyewash/safety shower units shall be provided in all work areas where, during routine operations or during foreseeable emergencies, the eyes of an individual may come into contact with a substance that can cause corrosion, severe irritation, or permanent tissue damage, or that is toxic by absorption.

At least one eyewash, initiated by a single action, shall be provided within every laboratory space, or for every two laboratory modules.

Eyewash units shall be designed to flush both eyes (double-headed unit) simultaneously and to provide hands-free operation. The eyewash units shall provide protection of the nozzle area with pop-off covers and other protective features to prevent contamination of the flushing system. Design, operation, flow, water temperature and similar characteristics shall meet the criteria in ANSI Z358.1. Water for the units shall be supplied by the potable water system. The temperature of flushing fluid for the emergency units shall be tepid (between 60 °F and 95 °F). Emergency eyewash units shall be provided with sanitary drains. Discharge from emergency eyewashes should not impinge on powered electrical equipment.

Eyewash units shall be in accessible locations that require no more than 10 seconds to reach. Their location in all laboratory spaces shall be standardized as much as possible. Units shall be placed in a location away from potential sources of hazard (e.g., fume hoods) and near the exit door. The location shall be well-lighted and clearly identified with a highly visible sign. Safety equipment must meet ABAAS accessibility requirements.

Emergency Safety Showers

Emergency safety shower units shall be provided in areas where, during routine operations or during foreseeable emergencies, areas of the body may come into contact with a substance that is corrosive, severely irritating to the skin or toxic by skin absorption. Each safety shower unit shall be equipped with an installed flexible hand-held drench hose with a spray head similar to that used in hand-held eyewash units; this shall be mounted on a rack. All piping for the emergency safety showers shall be above the ceiling, except for the showerhead and pull bar connection. Discharge from emergency showers should not impinge on powered electrical equipment.

Design, operation, flow rates and similar characteristics shall meet the criteria in ANSI Z358.1. Water for shower units shall be supplied by the potable water system. The temperature of flushing fluid for the emergency units shall be tepid, 60 °F to 95 °F. Rigid pull bars of stainless steel should be used to activate the shower and should extend to within 54 inches of the floor. The floor area of the emergency safety shower shall be textured, well-lit and identified with a highly visible sign.

Location of safety showers shall be standardized as much as possible. Emergency safety showers in laboratories generally shall be located at the room entrance on the right-hand side of the exit door (hinge side). Instrument laboratories and laboratory support spaces shall have showers located in the corridor at the pull side of the room door. Safety showers shall be provided in accessible locations that require no more than 10 seconds to reach from hazard locations, preferably inside or just outside the door of each laboratory work area. Safety showers should be no more than 50 feet travel distance from the hazard source. Safety equipment must meet ABAAS accessibility requirements. Refer the EPA Safety Manual for additional information.

Emergency safety showers located on the hinge side of exit doors must be clear of the door swing and at least 6 feet away from any electrical devices (e.g., switches, outlets, panels). Laboratory walls adjacent to the showers shall be water- and mold-resistant construction (e.g., mold-resistant gypsum, paperless gypsum board or coated with a waterproof coating).

The EPA recommends that modesty curtain(s) be provided at each safety shower location.

7.8 Energy and Water Metering

7.8.1 General Requirements for Advanced Metering

All newly installed meters must be advanced meters, which are meters that measure and record interval data at least hourly and transmit measurements to a remote central collection point at least daily. In addition, existing meters should be upgraded to advanced meters during major renovations.

The EPA has an enterprise-level energy management information system (EMIS) that collects data from advanced meters installed at EPA facilities. To transmit data to the EPA's enterprise-level EMIS, each facility shall have one or more remote terminal units (RTUs) installed that aggregate data from all onsite networked advanced meters. The Project A/E shall coordinate with the EPA Project Manager to determine which meters and submeters should be connected to the RTU(s) and the appropriate configuration of the RTU(s).

In addition, metered data must be available for use locally at the facility. All installed meters shall be compatible with the installed control system, be provided with signaling devices and seamlessly interface with the installed BAS. Refer to Chapter 9, Building Automation Systems, within these A&E Guidelines for additional information.

Where feasible, the Project A/E should consider opportunities to obtain output data from utility-provided revenue meters. In some cases, a digital pulse signal output from the utility-owned revenue meter may be sent to both the installed BAS and an EPA-owned RTU for transmission to the EPA's enterprise-wide EMIS.

For additional information about metering best practices, see DOE's *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency*.

Installation and Calibration

All meters and submeters shall be installed and calibrated in accordance with the manufacturer's specifications. Meter installation shall include calibration reports and point-to-point testing to ensure successful integration into EPA's enterprise-level EMIS, where applicable. The Project A/E shall coordinate with the EPA Project Manager and EPA Information Technology (IT) Administrators when integrating meters into the EPA's enterprise-wide EMIS to ensure proper metering hardware configuration.

The Project A/E shall include manufacturer's O&M requirements for all metering hardware in the project plans and specifications. In cases where meter maintenance would require critical system shutdown, a double block, bleed, and lockable bypass arrangement shall be installed to facilitate service, removal, and replacement. Additionally, for purposes of security, meters should be installed in lockable cabinets or be provided with tamper-proof transmitter enclosures.

7.8.2 Energy Meters

Where consumed, building-level energy meters must be installed for electricity, natural gas, steam, chilled water and high-temperature hot water. Exceptions are noted as follows:

- Per DOE's *Federal Building Metering Guidance*, building-level energy meters are not required for buildings less than 5,000 square feet, warehouses less than 25,000 square feet or food service/sales buildings less than 1,000 square feet. Buildings larger than these thresholds that do not have heating/cooling or other significant loads do not require building-level energy meters.

- Meters for steam, chilled water and high-temperature hot water are only required if these commodities are delivered to the building from a district energy system or central utility plant.

Electric Meters

Electric meters shall adhere to the following standards:

- ANSI C12.1, *American National Standard for Electric Meters—Code for Electricity Metering*.
- ANSI C12.7, *American National Standard for Requirements for Watthour Meter Sockets*.
- ANSI C12.18, *American National Standard for Protocol Specification for ANSI Type 2 Optical Port*.
- ANSI C12.19, *American National Standard for Utility Industry End Device Data Tables*.
- ANSI C12.20, *American National Standard for Electricity Meters—0.1, 0.2, and 0.5 Accuracy Classes*.
- ANSI C12.22, *American National Standard for Protocol Specification for Interfacing to Data Communication Networks*.

Electric meters shall be capable of reading and collecting the following data over 15-minute time intervals:

- Cumulative real power consumption (kWh).
- Real power demand (kW).
- Apparent power demand (kVA), average of three-phase total measured over the same demand interval as the real power demand.
- Reactive power demand (kVAR), average of three-phase total measured over the same demand interval as the real power demand.
- Power factor, average of three-phase total measured over the same demand interval as the real power demand.

Electric meters shall be capable of providing the following instantaneous measurements:

- Active (Real) Power (kW)—per phase and total.
- Apparent Power (kVA)—per phase and total.
- Reactive Power (kVAR)—per phase and total.
- Active (Real) Energy (kWh).
- Apparent Energy (kVAh).
- Reactive Energy (kVARh).
- Power Factor—per phase and total.
- Voltage (L-L, L-N)—per phase and total.
- Current—per phase.

Natural Gas Meters

To help ensure accurate measurement of the mass of natural gas consumed, natural gas meters shall be equipped with temperature compensation devices and installed downstream of pressure regulation devices. Natural gas meters shall be calibrated to the pressure resulting from the upstream pressure regulator. Meters shall comply with all applicable American Petroleum Institute (API) standards and be rated for accuracy within 2 percent. Natural gas meters shall be capable of reading and collecting therms and volumetric flow (cubic feet and hundred cubic feet [CCF]) over 15-minute time intervals.

Steam Meters

Steam meters shall be true mass flow type meters containing a packaged temperature compensation device. Steam meters shall be capable of reading and collecting total mass flow (pounds, for accuracy within 2 percent) over 15-minute time intervals, and flow rate (pounds per minute, pounds per hour) and temperature (°F) instantaneously.

High-Temperature Hot Water and Chilled Water Meters

High-temperature hot water and chilled water meters shall be capable of reading and collecting calculated energy consumption (Btu) over 15-minute time intervals, and supply temperature (°F), return temperature (°F) and flow rate (gpm) instantaneously.

7.8.3 Water Meters

Building-level water meters must be installed at all buildings, except those that are less than 5,000 square feet or expected to use less than 1,000 gallons of water per day. Permanent irrigation systems that provide water for landscaped areas equal to or larger than 25,000 square feet must be metered separately from indoor domestic water consumption.

Liquid flow meters shall be magnetic, turbine type, ultrasonic or other type approved by EPA. Flow meter accuracy shall be within ± 2 percent. The pressure drop across the flow meter shall not exceed 5 pounds per square inch gauge (psig) under maximum flow conditions. Wherever possible, a straight, unobstructed length of at least 10 pipe diameters shall be provided upstream of the flow meter and a similar straight, unobstructed run of at least 5 pipe diameters shall be provided downstream of the flow meter. Water meters shall be capable of reading and collecting total volumetric flow (gallons and CCF) over 15-minute time intervals, and flow rate (gallons per minute) instantaneously.

7.8.4 Other Fuel Meters

Flow meters for other fuels (e.g., fuel oil, biodiesel, propane) shall comply with API standards and shall be capable of reading and collecting total volumetric flow (gallons) over 15-minute time intervals, and flow rate (gpm) instantaneously.

7.8.5 Sub-metering

All sub-metered data shall be automatically fed to the BAS for archiving and report generation.

Electricity

Sub-metering shall be considered for lighting (interior and exterior), chillers, motors, and pumps.

Data Centers

In the EPA's data centers, advanced sub-meters shall be installed, unless the metering is not cost-effective and the EPA requests and receives an exemption from the Office of Management and Budget (OMB). The EPA Project Manager will provide further guidance regarding meter location(s) and the configured measurement interval.

Water

Individual equipment and subsystems that could consume more than 1,000 gallons of water per day shall be equipped with flow-totalizing submeters.

Solar Heating Systems and Solar Domestic Hot Water

Where solar heating systems and/or solar domestic hot water systems are installed, adequate sub-metering shall be installed to enable the EPA to monitor the performance and energy consumption of each system.

7.9 Other Measuring and Monitoring

7.9.1 Flow Meters for Air in Ducts

Wilson Grids (or similar airflow measuring grids) are required for all central AHUs. Measuring grids shall be provided at the supply air duct, return air duct and the outside air duct. Airflow measuring grids must be sized to give accurate readings at minimum flow. In some instances, it may be necessary to reduce the duct size at individual measuring stations to enable accurate measurement. Each grid shall be equipped with a pressure transducer linked with the BAS. Liquid-filled and/or electronic manometers to provide onsite readouts are optional.

Refer to Section 7.2, Ventilation Systems, within these A&E Guidelines for air duct requirements to guide the selection and placement of flow meters for air in ducts.

7.9.2 Temperature and Pressure Sensors

Each piece of mechanical equipment shall be provided with the instrumentation or test ports to measure and verify temperatures and pressures. These shall consist of permanently installed, calibrated sensors, such as pressure gauges, pitot tubes, manometers, thermometers, and/or thermocouples to accurately measure pressures and temperatures. Thermometers and pressure gauges are required on the suction and discharge of all pumps, chillers, boilers, heat exchangers, cooling coils, heating coils and cooling towers.

Pressure and temperature sensors shall comply with the requirements contained in Chapter 9, Table 9-1 Guidelines for DDC Systems, within these A&E Guidelines. Local chart recorders shall be installed where specified by the EPA.

7.9.3 Air Stack Monitoring

Air stack monitors shall be installed where applicable to measure releases of air pollutants, consistent with a permitted state synthetic minor source or Title V major source. Additional detailed information on stack monitoring will be contained in a facility's air emissions permit issued by the state or local environmental agency having jurisdiction.

7.9.4 Process Wastewater

The system shall have the capability of automatic, continuous monitoring and recording of wastewater discharge flow, pH and other constituents to conform with local POTW requirements. This typically will include continuous reading meters (e.g., for pH and temperature), and auto-composite samplers that collect hourly samples over a 12- or 24-hour period, for subsequent laboratory analyses.

7.10 Testing, Adjusting and Balancing of Mechanical Systems

The Construction Contractor shall retain an independent TAB contractor to balance, adjust, and test air-moving equipment and the air distribution system, water system, gas system, and compressed air piping systems, as applicable. The independent TAB contractor shall be an organization that is a member of the AABC and/or the NEBB.

8. Electrical Requirements

8.1 General Requirements

8.1.1 Design Calculations

The Project A/E shall provide:

- Calculations that show the available short-circuit currents at each bus and the voltage drop for each major cable run.
- Load flow calculations, including step loads, for switchgear, switchboards, panelboards and motor control centers.
- Inrush current calculations on all motor loads for commercial and emergency generators.
- Product and photometric data sheets for all lighting fixtures specified in the design and lighting calculations.
- Arc flash calculations, as well as a list of key risk areas and estimated hazard risk category, and a description of efforts made to reduce or mitigate arc flash issues.
- Supporting calculations and design solutions related to harmonic management for all large variable-speed drives with pulse-width-modulated speed control.

For any electrical generation assets, the Project A/E shall include electrical engineering calculations and design documentation that support integration with existing loads in the building and on the site as a whole.

8.1.2 Electrical Studies and Testing

The Project A/E shall include in the specifications requirements for a short circuit and coordination study to be provided by an independent testing agency. For minor projects, the Project A/E shall determine the need for either study and document findings in the BOD. The Project A/E shall modify the standard specification to conform to the project requirements. The following requirements shall be added to the standard coordination study specification: "Plots shall include the ground fault protective device settings along with the other overcurrent settings. Plots, which include ground fault protective devices, shall also include a typical 20-ampere downstream circuit breaker and a sampling of other downstream devices to show where coordination exists or does not exist between devices. Ground fault settings shall attempt to coordinate with downstream devices to the maximum extent practicable."

All major items of electrical equipment shall be tested in accordance with National Electrical Testing Association (NETA) and NFPA 70 standards by an independent testing agency. The specification section for each item of major equipment shall indicate the NETA section that specifies the testing to be performed. The Project A/E shall determine the appropriateness of all components of the tests and shall modify the standard test, if deemed appropriate. Testing specification for switchgear and switchboards shall require that the NETA standard for switchgear and switchboards have the section relating to inspection of bolted connections, replaced with the following: "Inspect all bolted electrical connections for high resistance. Check tightness of all bolted electrical connections by using a calibrated torque wrench. Each bolt shall be individually tested and individually marked to indicate that it has been tested. Refer to manufacturer's instructions or NETA Acceptance Testing Standards for proper torque levels."

For electrical systems with functions that are not adequately covered by the above standard tests, such as control systems, the Project A/E shall determine and specify system tests required and the acceptance criteria. NETA Section 8 "System Function Tests" shall be used as the basis of this requirement. The Project A/E shall reference a specific test code or procedure. If none is available, the Project A/E shall either:

- Provide and include in the specifications a test procedure to verify proper operation of the system; or

- Provide and include in the specifications lists of the functions that are to be tested, and require the testing organization to determine the appropriate testing procedures and submit them for approval.

8.1.3 Electrical Installations

Electrical installations shall maintain the integrity of fire stopping, fire resistance, fire separation, smoke control, zoning and other structurally oriented fire safety features in accordance with NFPA 70 and NFPA 101, *Life Safety Code*.

8.1.4 Demand-Side Management Systems

A demand-side management system to keep the peak demand of the facility below a predetermined level shall be evaluated. An economic analysis to determine the payback on such a system shall be performed. This system, if feasible, shall have the capability to follow the demand variations as an operator (or an automated software package) manually switches the loads.

8.1.5 Coordination of Work

A coordinated set of documents (i.e., coordination between architectural, electrical, HVAC, plumbing, equipment and structural systems for bidding) shall be provided. Documentation shall clearly identify the division of work among the trades and delineate the coordination responsibilities of the Construction Contractor. Special attention shall be given to designed-in equipment and equipment to be provided by the facility occupants.

8.1.6 Power Factors

The Project A/E shall design the facility's electrical system so as to assure that the overall power factor of the entire electrical installation is a minimum of 90 percent. This power factor may be achieved by selection of electrical utilization equipment with individual power factor ratings that would render the required facility power factor or through the installation of power factor correction devices to meet the overall facility power factor requirement. The Project A/E shall assure that certain groups of inductive loads, such as motors of 5 hp and above, fluorescent lighting fixtures, transformers, etc., are equipped with power factor correction at an individual level so that combined, the overall facility power factor will be attained. All required power factor correction devices shall be switched with the utilization equipment, unless doing so results in an unsafe condition. High-speed switching devices, especially pulse-width-modulated variable-speed drives, generate harmonic currents that could cause voltage distortion that could, in turn, create adverse conditions to the power system, including low power factor. Although harmonics are difficult to detect absent surveys and investigation, once they are detected, various filters can be applied to mitigate them. These methods include but are not limited to low-pass and tuned trap filters or line reactors that act as DC chokes.

8.2 Service Capacity

Incoming transformers must be provided, as required, and must be of sufficient capacity to accommodate the full design load plus 30 percent. To the greatest extent possible, public utility transformers shall be located outside of the actual building. If public utility transformers must be located within buildings because of site constraints, they shall be installed in standard transformer vaults conforming to the requirements of NFPA 70. These vaults shall not be located adjacent to, or directly beneath, any exit from the building. In calculating the design load, a demand factor of 100 percent shall be used for lighting and fixed mechanical equipment loads and a demand factor of 75 percent for all other loads.

8.3 Interior Electrical Systems

8.3.1 Basic Materials and Methods

The design of the electrical distribution system (both normal and backup power) shall take into account the effects that harmonics from nonlinear loads can produce on the system. Harmonics from nonlinear loads can affect the capacities of the neutral conductor, panelboards, phase conductors and emergency generators. "K" rated transformers shall be used where the associated panelboards are feeding a large quantity of nonlinear loads.

Special attention shall be given to the harmonics produced by variable-speed drives used for control of HVAC equipment.

8.3.2 Laboratory Power Requirements

Laboratory requirements shall be coordinated with the specified EPA laboratory SME.

8.3.3 Records Storage Facilities and Areas

Records storage facilities and areas shall be designed in accordance with the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

8.4 Lightning Protection

8.4.1 Scope of Design

A lightning protection system shall be provided for all facilities containing laboratory modules, as well as for facilities containing radioactive or explosive materials or facilities having research or communication towers/antennas. The requirements and installation criteria for lightning protection systems shall be in accordance with NFPA 780, *Standard for the Installation of Lightning Protection Systems*; UL 96A, *Standard for Installation Requirements for Lightning Protection Systems*; and the local building code.

For building types not in the above description, the guide in NFPA 780 shall be used to assess the risk of loss due to lightning.

8.4.2 Master Label

For buildings or facilities with a strong risk potential (per NFPA 780), equipment, accessories and material necessary for a complete master-labeled lightning protection system for all building components shall be furnished and installed. The system shall comply with NFPA 780, UL 96A and Lightning Protection Institute 175. All cables, lightning rods and accessories shall be copper. All connections and splices shall be of the exothermic weld type.

The installed system shall be unobtrusive, with conductors built during construction (so they are concealed). The system shall also be properly flashed and watertight. Installation shall be done in conformance with shop drawings prepared by the supplier and approved by the EPA.

Before the lightning protection system is accepted, the Construction Contractor shall obtain and deliver to the EPA Project Manager the UL master label or an equivalent certification.

8.5 Cathodic (Anti-Corrosion) Protection

An investigation shall be conducted and a determination made on whether cathodic protection is required for buried utilities. The Project A/E shall justify in writing the need or lack of need of a cathodic protection system for the type of construction and equipment specified for each specific buried utility. This evaluation shall be submitted with the first submission. If a cathodic protection system is required, a system shall be recommended to satisfy the local conditions.

The cathodic protection system shall be designed by a professional who is certified by NACE International as a Cathodic Protection Specialist or Corrosion Specialist or who is a registered professional corrosion engineer. Additionally, the design professional must have a minimum of 3 years of experience with similar installations. The cathodic protection design, as a minimum, shall comply with the applicable NACE International standard corresponding with the type of structure that is to be cathodically protected. The installed cathodic protection system shall be able to provide protective currents to the intended structure meeting the minimum performance criteria as defined in NACE International standards.

Any existing metallic USTs shall be cathodically protected; new USTs must be fiberglass or non-metallic construction. Refer to the EPA Environmental Management Manual for additional requirements concerning USTs.

8.6 Lighting Systems

The Project A/E must meet the *Guiding Principles for Sustainable Federal Buildings*, ENERGY STAR, and FEMP requirements for energy efficiency, daylighting, and lighting controls, and any other federal sustainable building requirements. The lighting design shall comply with the recommendations in *The Lighting Handbook* published by the Illuminating Engineering Society.

Occupancy/vacancy lighting sensors shall be provided for appropriate spaces, including, but not limited to, offices, conference rooms, restrooms, locker areas and storage rooms. For offices, conference rooms and other non-support rooms, the occupancy sensors shall be manual on/automatic off type. Occupancy sensors shall be located so they (1) have a clear view of the room or area they are monitoring; and (2) minimize instances when the lights are turned on by movement outside of the room.

Lighting systems and locations shall be selected to reduce glare at seated or standing working levels.

When conducting LCCAs for new lighting and controls solutions, the Project A/E shall evaluate the feasibility and cost-effectiveness of Power over Ethernet technology.

8.7 Backup Power Systems

Backup power systems shall be designed and provided for all administrative and laboratory spaces as required by code or directed by the EPA. Backup power loads are categorized based upon the intended end use and shall be designated based upon type, class and level as defined by NFPA 110 and NFPA 70. All backup power systems shall comply with NFPA 37, 70, 101, 110 and 111 and Institute of Electrical and Electronics Engineers (IEEE) 446. Acceptance testing of generators shall follow NFPA 110 for Level 1 systems.

Generators are not specifically required unless an analysis of the cost of installation and maintenance of acceptable backup power sources shows that a generator is the most cost-effective power source. However, local circumstances may indicate a generator as the only or most practical option. Regardless of the outcome of the design analysis for backup power, the EPA may require generator(s) to supply power.

Legally required/life safety generators may be designed to operate in parallel with the local utility, thus allowing for load shedding and smart grid and intelligent building initiatives. If a generator will ever be grid-tied, or if it will run in parallel with the grid, that generator shall comply with IEEE 1547, NFPA 70 and the serving electric utility's interconnection standards. Before designing generators for peak shaving purposes, local, state and federal authorities must be contacted, due to the need for possible noise, air quality permitting and additional hardware requirements.

The class must be a minimum of 72, which is the minimum time in hours for which the backup power system is designed to operate at its rated load without being refueled. Where a generator supplies a switchboard, power may be distributed from the switchboard to the legally required/life safety emergency, legally required standby and mission critical standby systems, in accordance with NFPA 110 Figures B.1 (a) and B.1 (b).

Diesel fuel and natural gas are permitted as energy sources for building generators. However, if natural gas/propane is selected for Level 1 and critical action facilities that may be located in areas where the probability of fuel interruptions is high (due to earthquakes, floods, poor utility reliability or operational/facility requirements), a risk assessment (e.g., probability and consequences) shall be developed that analyzes these types of parameters. This assessment shall also address issues such as block loading limitations, building height, seismic zone, continuity of tenant mission requirements, facility security, etc. The EPA Project Manager will make the final determination as to the fuel source assessment that will be utilized.

If possible, locate the generators outside and on grade. If installed outdoors, they must be provided with a suitable walk-in acoustic enclosure and jacket water heaters to ensure reliable starting in cold weather. If critical action structures must be located within a floodplain, generators shall be elevated above the 500-year base flood elevation.

When installed at high altitudes or in areas with very high ambient temperatures, the generators must be derated in accordance with the manufacturer's recommendations. Operation of starting batteries and battery chargers must also be considered in sizing calculations. In humid locations, heaters can reduce moisture collection in the generator windings. Temperature and ventilation must be maintained within the manufacturer's recommendations to ensure proper operation of the unit. Calculations to support the size of the intake air supply for combustion, cooling and radiation, as well as exhaust piping and exhaust paths, must be provided by the mechanical engineer. Refer to Section 7.1.9, Mechanical Rooms, within these A&E Guidelines for design requirements for mechanical rooms that house generators.

Critical silencers are required for all generators. Acoustical treatment of the generator room must be provided as necessary.

Radiators must be unit-mounted if possible. If ventilation is restricted in indoor applications, remote installation is acceptable. Heat recovery and load shedding must not be considered. The remote location of radiators must be designed to avoid excess pressure on the piping seals.

A permanently installed load bank, sized at a minimum of 50 percent of generator rating, must be provided. The load bank may be factory-mounted to the radiator. Care should be taken in selecting materials that will tolerate the high temperatures associated with radiator-mounted load banks to include belts, flex connections, motors, sprinkler heads, etc.

For diesel generators, the load bank shall provide a load add/shed feature that will maintain load levels at a minimum, including building load, of the generator manufacturer's recommended loads when operating at 50 percent of generator kW name plate. The load bank shall have a minimum of four automatic load taps controlled by a load add/shed relay incorporated into the run circuit on the generator.

The engine generators must be sized to serve approximately 150 percent of the design load and to run at a maximum of 60 percent to 80 percent of their rated capacities after the effect of the inrush current declines. When sizing the generators, the initial voltage drop on generator output due to starting currents of loads must not exceed 15 percent.

Day tanks must be sized for a minimum capacity of four hours of generator operation. Provide direct fuel oil supply and fuel oil return piping to the onsite storage tank. Piping must not be connected into the boiler transfer fuel oil delivery "loop."

Care must be exercised in sizing fuel oil storage tanks by taking into account that the bottom 10 percent of the tank is unusable and that the tank is normally not full (normally at a 70 percent level) before the operation of the generator.

Generator alarms must be provided on the exterior wall of the generator room. All malfunctions must be transmitted to the BAS. In all buildings, with or without a BAS, a generator alarm annunciator must be located within the fire command center. The generator output breaker must have a contact connected to the BAS indicating output breaker position, to allow annunciation of the open position on the BAS.

Automatic transfer switches serving motor loads must have in-phase monitors (to ensure transfer only when normal and emergency voltages are in phase) to prevent possible motor damage caused by an out-of-phase transfer. They must also have pretransfer contacts to signal time delay returns in the emergency motor control centers.

Automatic transfer switches must include a bypass isolation switch that allows manual bypass of the normal or emergency source to ensure continued power to emergency circuits in the event of a switch failure or required maintenance.

The generators and the generator control panel must be located in separate rooms or enclosures.

To readily identify all receptacles and electrical outlets that are part of the backup power system, each receptacle and the associated cover plates shall be red in color. In addition, the cover plate shall have a professional quality label attached that identifies the circuit and the device number on that specific circuit.

All new generators must be monitored by the fire alarm system for the following supervisory conditions: Generator Running, Generator Fault and Generator Common Trouble. In addition, the generator controllers must include the NFPA 110 required generator monitoring and output contacts.

When a generator is installed, a mushroom-type disabling switch shall be installed adjacent to the fire alarm annunciator panel. If the facility does not have a fire alarm system or annunciator, this switch shall be located at the main entrance to the facility. The switch shall also be provided with a plastic cover to prevent accidental activation of the switch. This location is the normal/traditional point that fire department personnel responds to at the facility. If the fire department needs to disable the generator to gain control of the utilities, it must be easily recognizable and accessible. Placing the switch in an electrical room and expecting fire department personnel to have institutional knowledge of that location is unacceptable. Additional switches can be installed for maintenance and facility personnel, but not in lieu of the switch at the fire alarm annunciator.

8.7.1 Legally Required/Life Safety Emergency Power

Per NFPA 110, life safety emergency power shall be considered Level 1 systems. Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries. Level 1 systems are intended to automatically supply illumination or power, or both, to critical areas and equipment in the event of failure of the primary supply or in the event of danger to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life. The system shall provide electric power in the event of loss of normal power and shall provide power for emergency and egress lighting. The transfer of power shall be within 10 seconds or a Type 10.

Legally Required/Life Safety Emergency Power Loads

Loads requiring dedicated emergency power supply are specified by NFPA 70, NFPA 101 and some local building codes. Automatic switching schemes shall be provided for all emergency power sources. Where emergency generators are used, their installation shall be in accordance with NFPA 110 and NFPA 70, Article 700. Distribution for loads shall be located in separate vertical sections of switchgear or switchboards or in dedicated panels.

Examples of life safety loads required by NFPA 70 to meet Article 700 include:

- Fire alarm systems.
- Exit signs and means of egress illumination.
  - Emergency lighting system: 3 footcandles minimum for egress, 10 footcandles at switchboards.
- Emergency and public safety voice/alarm communication systems.
- Automatic fire detection systems.
- Electrically powered fire pumps and jockey (pressure maintenance) pumps.
- Industrial processes where current interruption would produce serious life safety or health hazards; some of these processes may require uninterruptible power supply (UPS) power.
- Essential ventilating where failure could result in serious life safety hazards.
- Occupancies with silane gas.
- Emergency circuits.
- Emergency source (generator).
- Transfer switches.
- Emergency panels.

8.7.2 Legally Required Standby Power

Per NFPA 110, legally required standby power systems shall be considered Level 2 systems. Level 2 systems shall be installed where failure of the backup power system to perform is less critical to human life and safety. Level 2 systems typically are installed to serve loads when stopped due to any interruption of the primary electrical supply, could create hazards or hamper rescue or firefighting operations. Legally required systems shall meet all requirements in NFPA 70 Article 701. These systems shall transfer power within 60 seconds as a Type 60.

Legally required standby power loads include, but are not limited to, the following:

- Smoke control systems.
- Accessible means of egress platform lifts.
- Power and lighting for the fire command center.
- Certain HVAC and exhaust systems (as required by applicable state and local codes and as directed by the EPA Project Manager).
- Critical sump pumps and other associated mechanical equipment and controls.
- BAS, if supporting legally required systems.
- All animal care facilities.
- Local HVAC air compressors for special rooms.
- Selected elevators (as required by applicable state and local codes and as directed by the EPA Project Manager).
- Generator auxiliaries.
- Federal Aviation Administration (FAA)-required aircraft obstruction warning lights.
- UPS serving technology/server rooms that serve legally required communications systems.
- Storage battery (required to carry load for 1.5 hours).
- Generator set.
- Fuel cell.
- Exhaust fan in UPS battery rooms.
- Power and lighting for Fire Command Center and Security Control Center.
- Heating and refrigeration systems for legally required systems.
- High-rise stairway pressurization fans.
- Elevator machine room lighting, HVAC and power.
- Emergency responder radio coverage.
- Visitor screening equipment.
- Telephone switches and fiber cable battery systems.
- Security systems.
- Drinking water booster pumps (high-rise buildings).
- Sewage ejector pumps.

8.7.3 Mission Critical Standby Power

Based upon the mission of the facility, certain equipment may need power to continue mission critical operations or to support an orderly shutdown process but do not impact the life safety of the occupants. These systems are defined in NFPA 70 Article 702 and include:

- General areas of the buildings.
- Horizontal sliding doors.
- UPS serving technology/server rooms.
- Selected heating and refrigeration systems.
- Selected refrigerators and freezers (as directed by the EPA Project Manager).
- Air-conditioning systems associated with computer rooms, UPS rooms and environmental rooms.
- Boiler, hot water pumps, perimeter HVAC units and any other ancillary heating equipment necessary to freeze-protect the building.
- BAS, if not supporting legally required standby or life safety systems
- Optional non-egress lighting.
- Industrial processes.
- Receptacles and emergency lighting in large conference rooms to facilitate command and control operations during an emergency situation.
- Other equipment as directed by the EPA not required by codes.

8.7.4 Uninterruptible Power Supplies

A UPS system shall be provided for loads requiring guaranteed continuous power or a Type U. The application of UPS systems shall comply with IEEE 446 and NFPA 111. The Project A/E shall make a recommendation concerning the appropriate type of system for a particular facility (i.e., rotary or stationary [static] type). UPS equipment shall be capable of supplying power through multiple means (e.g., normal, static switch bypass, total system bypass).

The UPS system shall be sized according to the criticality of the area served, with a minimum of 5 minutes of protection upon loss of normal power or a Class 0.083. The UPS system shall be rated for “multi-range” input voltage and shall provide a sinusoidal or, as a minimum, a quasi-sinusoidal power output wave form. Total system bypass power shall include an isolation transformer. All components shall be UL-listed. The supplied UPS system shall be specified to operate properly with an emergency generator.

8.7.5 Security Systems

ISC’s *The Risk Management Process for Federal Facilities, Appendix B: Countermeasures* indicates uninterruptable power for security systems must be comprised of batteries, emergency generators, UPS system or a combination thereof to meet a minimum system operational period of four hours.

IDS must have sufficient power to operate for the four-hour minimum in a non-alarm state and five minutes in alarm.

All VSS components (e.g., network switches, encoders, monitors, recorders, cameras) must operate for a minimum of four hours to obtain, view and record motion video.

More than four hours of power may be required in areas with frequent and extended periods of power outage, or for facilities with a mission that warrants a higher minimum. The facility’s physical security risk assessment must be used to determine the appropriate duration of backup power to be implemented.

8.8 Telecommunications Systems and Spaces

8.8.1 General Requirements

All telecommunications systems shall be designed by the Project A/E and provided by the Construction Contractor, including, but not limited to, pathways, cabling, bonding and grounding. The Project A/E shall coordinate with the EPA to confirm project-specific telecommunications requirements and to address security and audiovisual system needs within the telecommunications rooms and data center. Furthermore, the Project A/E shall ensure bonding and grounding of the telecommunications system is integrated with the building electrical grounding and lightning protection systems. Telecommunications systems shall meet applicable industry standards, including those published by the Telecommunications Industry Association (TIA), Building Industry Consulting Service International (BICSI) and organizations listed in Appendix A.

If the building is located in an area susceptible to severe weather and flooding, place telecommunications equipment in centrally located areas above the local design flood elevation or 3 feet above the base flood elevation (whichever is higher), avoid placing telecommunications equipment in below-grade spaces where water is most likely to enter, and run wiring and cables along ceilings—not floors—wherever possible.

All cabling and connectors shall meet Category 6A performance standards as defined by TIA 568.

8.8.2 Local Area Network/Telecommunications Rooms

Local area network (LAN)/telecommunications rooms shall meet the following requirements:

- **Number:** Each EPA-occupied floor shall have at least one enclosed telecommunications room. The number required per floor will depend on the size of the floor plate.
- **Location:** Telecommunications rooms shall be vertically stacked within the building and shall be located in accordance with TIA and industry standards to avoid potential sources of electromagnetic interference, flooding, or fluid or gas leaks. Access to these rooms shall be directly from hallways, not through offices or mechanical spaces.
- **Size:** The preferred room dimensions are 10 feet by 10 feet. Actual size will depend on the building occupancy and need.
- **Equipment:** Each room will house communications equipment racks, switches and, if required, supplemental cooling units.
- **Sleeves:** Each room shall house an integral cable riser pathway consisting of two 4-inch sleeves (vertical and horizontal), including one that may be designated for the use of the EPA's security systems.
- **Cable Support:** Where needed, ladder racks shall be provided that are 12 inches wide and suspended from the ceiling slab to allow adequate clearance for equipment and installation.
- **Use Restrictions:** Building management systems and other base building service panels shall not be housed in these rooms. The EPA's security system panel and audiovisual equipment may be housed in these rooms.
- **Architectural and Finishes:**
  - **Partitions:** Rooms shall be enclosed with slab-to-slab drywall partitions with a minimum 1-hour fire rating.
  - **Ceilings:** Ceilings shall be exposed to the slab above, and the slab shall be sealed to reduce dust.
  - **Floors:** Floors shall be slab and sealed with a static dissipative coating of light color.
  - **Doors:** Room doors shall be 36 inches wide by 96 inches high, open outward with 180° hinges, have automatic door closers and be lockable with a PACS reader and key override.

   - **Backboards:** Plywood backboards shall be provided and installed in accordance with TIA 569.

- **HVAC:** Room temperature and relative humidity must be maintained at 80 °F ± 2 °F and 50 percent ± 5 percent, respectively, 24 hours per day, seven days per week. The Project A/E shall verify specific equipment heat loads and other requirements for each room prior to finalizing design. If required to maintain temperature and humidity, dedicated HVAC units shall be provided and be up flow and/or down flow units. Supply air shall be provided to the rooms to meet the code-required outdoor air rate.
- **Electrical:** The electrical load shall be calculated based on the equipment in the room, and UPS outlets shall be provided as required to connect all equipment to the central telecommunications UPS. In addition, two convenience 120V AC quad outlets shall be provided on separate walls and be connected to the standby power system. Bonding and grounding shall be provided in accordance with TIA 607.
- **Lighting:** Lighting shall meet relevant industry standards and shall provide appropriate emergency lighting.

8.8.3 Data Center

Determining Need and Receiving Approval for a Data Center

Depending on the building occupancy and need, the facility may have a data center. Per the "FITARA Enhancement Act of 2017" and the OMB "Data Center Optimization Initiative" policy, the EPA must submit justification to and receive approval from OMB before budgeting funds or resources toward initiating a new data center or significantly expanding an existing data center. If a new or modified data center is required and approved, the Project A/E shall follow the design requirements below.

Design Requirements

Depending on the facility's needs, the data center may be comprised of one or more of the following rooms: Main Computer Room, Burn-in Room and Storage Room.

All rooms of the data center shall meet the following requirements:

- **Location:** The data center shall be located centrally within the EPA's occupied space, above grade and preferably away from exterior walls. The data center shall be isolated from interference caused by high voltage transmission lines and radio transmission facilities. Access to the data center from the loading dock shall be sufficiently wide and structurally adequate to handle future equipment replacement.
- **Size:** Each room shall be sized to accommodate the anticipated equipment.
- **Architectural and Finishes:**
   - **Ceilings:** The data center must have a ceiling with a minimum of 9 feet of clearance above the finished floor; if unable to meet this requirement, the Project A/E shall request a variance from the EPA. No pipes (e.g., water, waste, fuel) are permitted to run overhead.
   - **Floors:** The floors shall be clean, structural floors. See Section 6.3, Floor Loading, within these A&E Guidelines for the minimum live load capacity.
   - **Doors:** The doors leading to each room shall be 4 feet wide or standard double doors. Access to each room shall be controlled with PACS readers and have a key override.
- **Electrical:** Electrical power and distribution for the data center rooms shall be sized based on the actual computer equipment to be used. Bonding and grounding shall be provided in accordance with TIA 607.
- **Lighting:** Lighting shall be distributed over two circuits. Emergency egress lighting shall be tied into the emergency power system with battery backup.

- **Monitoring:** Automated monitoring and management tools shall be implemented in accordance with the latest OMB "Data Center Optimization Initiative" policy. See Section 7.8.5, Sub-metering, within these A&E Guidelines for data center advanced sub-metering requirements.

Additional data center room-specific requirements are as follows:

- **Main Computer Room:** The Main Computer Room houses all file servers, switches and other centralized computer equipment, including associated server racks, telecommunications racks, power distribution units/UPSs, computer room air handler and air conditioning units, and workbenches.
  - The room shall be enclosed with slab-to-slab walls with a minimum 1-hour fire rating.
  - The HVAC system serving this room shall be separately zoned and available 24 hours per day, seven days per week, with N+1 redundancy. Room temperature and relative humidity must be maintained at 80 °F ± 2 °F and 50 percent ± 5 percent, respectively, on an ongoing basis. Air provided to the Main Computer Room must be filtered with MERV 13 filters. See Section 7.5.8, Data Center Cooling, within these A&E Guidelines for energy-efficient data center cooling strategies. Audible and visual alarms shall be generated at the BAS front end in the event of power or mechanical equipment failure or when the room temperature rises above 87 °F.
  - Adequate distribution of 120V and 240V receptacles shall be provided.
  - All equipment shall be connected to the UPS. Dedicated circuits shall be provided for UPS and power conditioning equipment.
  - Standby power capacity for this room shall be provided for all equipment and necessary functions, including power, lighting and HVAC.
  - An emergency power off (EPO) switch with a 15-second delay shall be installed 3 feet above the finished floor within 1.5 feet of the exit door. The EPO switch shall control all circuit breaker feeds into the Main Computer Room. When the EPO is activated, these circuit breaker power feeds shall trip to the off/open condition. EPO circuit activation shall also generate an alarm report at the BAS.
  - Per the OMB "Data Center Optimization Initiative" policy, when installing new servers, the EPA will purchase EPEAT-registered servers, where feasible.
- **Burn-in Room:** The Burn-in Room provides an area for IT personnel to configure, test and repair various IT equipment.
  - The room shall be adjacent to the Main Computer Room.
  - Workbench space and shelving is needed, as well as some enclosed storage cabinets.
  - The type and quantity of equipment that will be tested is likely to require a level of cooling and exhaust beyond that normally provided to typical office spaces, but does not need to be available 24 hours per day, seven days per week.
- **Storage Room:** The Storage Room will be used for the temporary storage of IT equipment scheduled for repair, burn-in or installation, as well as the permanent storage of associated parts and other IT appurtenances.

8.8.4 Sound Masking

A sound masking system shall be considered when the facility already has, or is installing, a building-wide public address system. The EPA does not require sound masking systems at all facilities; the EPA Project Manager shall coordinate with appropriate representatives from the affected facility to decide whether installation of a sound masking system is necessary and, if so, to develop the system's requirements.

This page intentionally left blank.

9. Building Automation Systems

A BAS will be required for all new facilities and major renovations of existing facilities. Smaller projects shall be evaluated on a case-by-case basis to determine the need for—or suitability of—a BAS. The following factors shall all be considered in the decision to specify and install a BAS:

- Size of the building.
- Number of pieces of equipment.
- Complexity of equipment and systems.
- Potential magnitude of energy savings.
- Availability of properly trained and experienced personnel.

The BAS at new facilities or those that have undergone major renovations will have a high degree of intelligent building functions including:

- Data retrieval, storage and manipulation.
- Self-diagnostic capabilities.
- Three-dimensional building information modeling capabilities.

The EPA's Office of Environmental Information has identified the BAS as a potential cybersecurity vulnerability. The GSA has developed policy and guidance to address this security vulnerability, including the *Technology Policy for PBS-Owned Buildings Monitoring & Control Systems*, the *GSA PBS FMSP Smart Building Technology Guide* and the *GSA PBS FMSP Smart Building Technology Guide*. The EPA also has specific guidance; contact the EPA Project Manager for details.

9.1 Direct Digital Control Network

The BAS shall be an interconnected network of DDC systems supervised by a central computer. The BAS shall possess a fully modular architecture, permitting expansion through the addition of stand-alone control units, modular building controllers, unitary controllers, digital point units, multiple point units, terminal equipment controllers, operator terminals and control computer(s). DDC signals shall be arranged to precisely sequence heating valves, dampers and cooling valves without overlap. Unless otherwise specified, sequenced devices will have a separate DDC output for each device; spring range sequencing will not be permitted. In addition, each start/stop function shall be controlled from a separate DDC output. DDC controllers shall be electronic (unless pneumatic controls would provide greater energy efficiency and/or speed of response).

Standard control functions that use open-loop logic (i.e., without feedback to related systems and indirect control logic) are inappropriate in BAS control sequences, which instead require closed-loop control logic to assure feedback to related systems.

The BAS shall utilize "open" communication protocols, such as Building Automation and Control Networks (BACnet), LonWorks™ or equivalent, to minimize the costs of providing integration and allow interoperability between building systems and control vendors. Other open protocol language systems, such as LonTalk™, may also be used provided there is compatibility with overall regional and/or central monitoring and control systems and strategies. The BAS shall include energy management and monitoring software. The BAS shall have a graphical user interface (GUI) and offer the following features:

- Trending.
- Scheduling.
- Capability to download memory to field devices.

- Real-time, live graphics programs.
- Parameter changes of properties.
- Set point adjustments.
- Alarm/event information.
- Confirmation of operators.
- Execution of global commands.

The BAS shall be designed and installed to provide master control over all building systems and functions. Based on project requirements, the EPA may require that one or more of the following systems be operated by control panels and networks that are independent from the BAS:

- Lighting.
- Fire alarms.
- Security.
- Elevators.

The BAS system shall coordinate with, but not limited to, the following systems:

- Heat recovery systems.
- Thermal energy storage systems.
- CO sensors.
- Confined space gas sensor alarms.
- Metered and sub-metered data analysis and storage.
- Methane detectors for gas-fired equipment.
- UST leak detection.

Table 9-1 contains guidelines for DDC systems, which may be modified depending on project-specific requirements.

Table 9-1: Guidelines for DDC Systems

Control Parameter	Range of Control	Sensitivity	Display
Space Temperature	50 °F – 85 °F	± 1.0 °F	Nearest 0.5 °F
Duct Temperature	30 °F – 130 °F	± 1.0 °F	Nearest 0.5 °F
Heated or Chilled Water Temperature	40 °F – 280 °F	± 1.0 °F	Nearest 0.5 °F
Duct or Building Static Pressure	Design-Specific	± 25% of Range	Nearest 0.01 inches of water column
Space Relative Humidity	10% – 90%	± 3%	Nearest 1%
Duct Humidity	0% – 100%	± 5%	Nearest 1%

A BAS requires measurements at key points in the building system to monitor part-load operation and adjust system set points to match system capacity to load demand. Table 9-2 and Table 9-3 list the minimum control points and monitoring parameters for typical HVAC systems and equipment.

Table 9-2: Minimum Control Points for HVAC Systems

System Component	Control Points	Alarms
AHUs and Terminal Boxes (Constant Volume and VAV)	• Start/stop supply and exhaust fans • Heating control • Cooling control • Humidification control • Supply air volume reset • Adjustable supply air volume (VAV) • Static pressure reset • Zone temperature reset (each zone) • Zone pressurization control (each building zone) • Damper position (economizer) • Enable/disable economizer cycle • CO_2 concentration • Terminal unit damper position • Space pressure or CFM offset (laboratory spaces)	• Fan failure • Zone space temperature rise of 5 °F above set point • Zone relative humidity of 5 percent below set point • Freeze-stat activation • High and low static pressure cut-outs • High humidity limit • Space pressure above or below offsets • CFM above or below offsets
Chillers	• Start/stop • Leaving water temperature reset • Isolation valve position	• Failure • Chilled water temperature rise of 5 °F above set point • Chilled water pump failure • Release of refrigerant
Hot Water Boilers	• Start/stop • Leaving water temperature reset • Isolation valve position	• Hot water decrease of 5 °F below set point • Hot water pump failure • Common boiler failure point
Cooling Towers	• Start/stop • Leaving water temperature reset • Isolation valve position • Fan speed	• Fan failure • Backside cooling loop pump failure • Basin heater cutout
Pumps	• Start/stop • Differential pressure reset	• Pump failure
Other	Not applicable	• Water on floor of Mechanical Room • Laboratory fume hood sash position and hood alarm condition

Table 9-3: Minimum Monitoring Parameters for HVAC Systems

System Component	Monitoring Parameters
AHUs and Terminal Boxes (Constant Volume and VAV)	• Supply air temperature • Return air temperature • Mixed air temperature • Leaving chilled water temperature • Entering chilled water temperature • Leaving hot water temperature • Entering hot water temperature • Temperature and humidity in each zone • Fan speed • Differential pressure across filter(s)

System Component	Monitoring Parameters
	• Supply airflow rate • Exhaust airflow rate • Outside air intake flow rate (AHUs) • Room or zone CO_2 concentration • Damper position • CFM offset (laboratories and vivaria)
Chillers	• Leaving water temperature • Entering water temperature • kW draw • Leaving water flow rate
Hot Water Boilers	• Leaving water temperature • Entering water temperature • Leaving water flow rate • Btu draw
Steam Boilers	• Leaving water temperature • Entering water temperature • Leaving water flow rate • Btu draw • Flue gas temperatures • Steam pressure
Cooling Towers	• Entering water temperature (from condenser) • Leaving water temperature (to condenser) • Backside cooling loop water temperature (in) • Backside cooling loop water temperature (out) • Fan speed • Basin heater temperature
Pumps	• Differential pressure • Liquid flow rate
Utilities	• Natural gas consumption • Electricity consumption • Electricity demand • Make-up water consumption • Fuel oil consumption • District-supplied hot water • District-supplied chiller water • District-supplied steam temperature and pressure
Fume Hoods (laboratories) and Ductwork	• Fan start/stop • Static and dynamic pressure • Volumetric flow rate (cfm) • Fume hood face velocity • Fume hood sash position

The system shall be capable of logging all data listed above or a subset of these parameters selected by building operators. In all new buildings and major renovations, the BAS shall have at least 20 percent spare capacity for future expansion. The system must provide for stand-alone operation of subordinate components. The primary operator workstation(s) shall have a graphical GUI. Stand-alone control panels and terminal unit controllers shall have hand-held or fixed, text-based user interface panels.

9.1.1 Control Computer Hardware Requirements

Control computer hardware shall consist of, at a minimum, one portable (laptop) workstation/tester and one central workstation/tester. All hardware shall have the capabilities to:

- Run DDC diagnostics.
- Load all DDC memory resident programs and information, including parameters and constraints.
- Display any point in engineering units for analog points or status for digital points.
- Control any analog output or digital output.
- Provide an operator interface, contingent on password level, allowing the operator to use full English language words and acronyms, or an object-oriented GUI.
- Display and modify database parameters.
- Accept DDC software and information for subsequent loading into a specific DDC (provide all necessary software and hardware required to support this function, including an ANSI/EIA/TIA 232-F port).
- Disable and enable each DDC.

9.1.2 Building Automation System Controllers

BASs generally rely on network controllers that communicate to a server and control edge devices. These controllers are generally the system engines, making the majority of the control decisions. The following apply for all BAS controllers:

- BASs shall be 100 percent DDC systems, utilizing a server, controller, edge device hierarchy.
- BAS controllers shall be programmed to maintain schedules, set point and normal operation control in cases of network connection loss. Network connection loss scenarios shall be tested and verified as part of the commissioning process for any BAS.
- BAS controllers should be capable of storing data and uploading data in case the server connection is lost.
- BAS controllers should host graphics or terminal interfaces to allow for direct connection and control from a workstation for emergency control. This could be accomplished over Internet Protocol, serial or USB connections.
- BAS controllers should have embedded tools or means to direct connect that allow for troubleshooting or programming in cases of communication loss. Means to “direct connect” to building system controls could include Internet Protocol, serial or USB connectivity options.
- BASs are subject to fire protection/life safety requirements (e.g., fire alarm systems may permit read-only data interchange with, but may not share control infrastructure with, other BASs).

9.1.3 Building Automation System Software

The BAS person-machine interface (PMI) software is the major influence in complex situations, such as the handling of trouble calls and alarms reported by the BAS. These calls are a complicated mix of:

- The type of call/alarm.
- The criticality of the alarm.
- The individual(s) required to respond.
- The time of day.
- The troubleshooting ability of the respondent.

- The comfort level that the respondent to the call feels toward the PMI, which is the major variable in the response to alarms and trouble calls.

All required software to operate the BAS (including all DDC functions) shall be furnished as part of the complete DDC system. Updates to the software shall be provided upon commercial release and incorporated into O&M manuals, as part of the required technical support for the software products.

In accordance with GSA PBS-P100, any BAS software systems must follow IT requirements. These requirements include:

- All Internet Protocol addressable devices must complete the scan and remediation process.
- All networking infrastructure (switches, routers, servers and workstations) must be government furnished.
- BAS software must be installed in the EPA environment, including server software, client software and any additional tools needed for management and control of the system. This includes system update tools, network management tools and any software that is used to make changes to the controllers.
- BAS software shall be compatible with the most current version of required standard software and all operating system and database software updates (i.e., Microsoft Server, Linux, SQL, etc.)
- BAS software must be capable of trending and exporting data.
- BAS software shall have multiple user level controls, including administrator, programmer and users. These user levels shall be capable of an audit to determine operator’s use.
- BAS software credentials shall be unique for every user.
- BAS software shall be installed with a minimum number of licenses needed for system use. In cases of virtual environment installation, the number of licenses required should consider offsite users.
- BAS client software shall have point-and-click graphics, configured for system operators, unless a unified user interface is included in the project scope.
- BAS software licenses shall be software licenses and not rely on a physical license key or dongle.
- BAS must be licensed to the EPA. End user license agreements (EULA) must be approved prior to installation onto equipment.

9.1.4 Wireless Sensor Technology

Installation of wireless sensor technology should be considered for control, metering and monitoring devices. The primary components of a wireless sensor data acquisition system include:

- Sensors.
- Signal conditioners.
- Transmitters.
- Repeaters (optional).
- At least one receiver.
- Computer (if data processing is planned).
- Connections for external communications to users (e.g., building operators).

Table 9-4 lists common wireless sensor types and the applications for which they shall be considered.

Table 9-4: Wireless Sensor Types and Applications

Frequency Band (MHz)	Topology and Communications	Applications	Power Source
900	Point-to-multipoint; serial-FHSS	• Building temperature sensing • Electric power metering • Building security	• Temperature sensors—battery powered • Receivers—line powered with 24 VAC power supply • Repeaters—line powered with battery backup
	Point-to-point and point-to-multipoint; serial	• Remote monitoring with long-distance communication • Building to building communication • Remote facility monitoring	• 11 VDC to 25 VDC from power supply connected to line power
2,400	Point-to-point; serial	• Temperature, humidity and other parameter monitoring	• 10 VDC to 30 VDC from power supply connected to line power
900 and 2,400	Mesh network	• Temperature, humidity, occupancy and other building parameters	• Battery- or line-powered
Cellular Network Bands	Point-to-point and point-to-Internet	• Monitoring of electrical power use and other critical parameters	• Battery- or line-powered

FHSS – frequency-hopping spread spectrum; MHz – Megahertz; VAC – volts, alternating current; VDC – volts, direct current

9.1.5 Design Considerations

The design submittal shall include complete control system drawings, complete technical specifications and sample commissioning procedures for each control system that is in turn a component of the BAS. The control logic, once in place, dictates the efficacy of the BAS. Potential opportunities for optimization of the system include, but are not limited to:

- Device/system start/stops.
- Temperature resets.
- Temperature setbacks.
- Operation schedules.
- Control loop tuning.

9.1.6 Point Naming Conventions

In accordance with GSA PBS-P100, all new construction, energy savings performance contracts (ESPCs), or repairs and alterations shall utilize a point naming convention for standardization of point naming. The term “point” is a generic description for the class of object represented by analog and binary inputs, outputs, and values either physical or virtual. All systems shall use this naming convention and process, and point naming shall be consistent through system drawings, records, files and documents.

9.1.7 Laboratories

BAS control requirements for unique and diverse laboratory environments have additional considerations and requirements.

Proper location of sensors is critical in a laboratory environment to avoid potential performance deficiencies, malfunction or damage. For example, temperature sensors can usually be installed in locations where chemicals are used and/or surfaces are routinely sanitized. In contrast, humidity sensors can be very sensitive to chemicals and must be protected from normal sanitizing procedures.

Laboratory ventilation shall be monitored either directly with flow sensors or indirectly with pressure differential sensors in ductwork or between adjacent areas. Fan motors shall be equipped with current monitors and alarms that indicate impending failure of the motor. Humidification monitoring can be provided within the duct system or in various areas of the laboratory where humidity ratio is critical. To ensure isolation of laboratory operations (and potential hazards thereof), sensors shall be installed to monitor the differential pressure between the laboratory space and the support space.

Certain laboratory operations may require cooling water on a routine and/or emergency basis. In those situations, appropriate sensors and controls shall be installed to enable delivery of cooling water, as required.

Animal room environmental conditions (e.g., temperature, humidity, ventilation airflow) must be monitored consistent with applicable safety and animal welfare standards. Environmental monitoring systems in animal rooms should be combined with automatic watering, through-flush and access control system packages, where feasible.

9.2 Automatic Controls

Pre-programmed and stand-alone single or multiple loop microprocessor proportional integrative derivative controllers shall be used to control all HVAC and plumbing subsystems.

9.2.1 Temperature Controls

All chillers, boilers, terminal boxes, and AHUs shall have self-contained BACnet or LonWorks controllers (or equivalent) that can communicate with the BAS. Heating and cooling energy in each zone shall be controlled by a thermostat or temperature sensor located in that zone. Independent perimeter systems must have at least one thermostat or temperature sensor for each perimeter zone.

Temperature inputs shall be a signal from resistance temperature detector (RTD) elements or precision thermistors, depending on cost and the accuracy required by the application. Temperature sensors using RTDs should include platinum elements. In systems and applications with high time constants (e.g., large rooms and laboratories), temperature sensors shall be thermistors as opposed to RTDs.

A 5 °F dead band shall be used between independent heating and cooling operations within the same zone. Simultaneous heating and cooling (i.e., conditioning the space by reheating or re-cooling supply air or by concurrently operating independent heating and cooling systems serving a common zone) shall not be used, except under the following conditions:

- Renewable energy sources are used to control temperature and/or humidity.
- Project-specific temperature, humidity, or ventilation conditions require simultaneous heating and cooling to prevent space relative humidity from risk above space-specific or facility-specific requirements (e.g., specialized laboratory spaces).
- Project-specific building construction constraints prohibit installation of other types of HVAC systems. (The EPA must review these cases and provide pre-approval.)

Night set-back and set-up controls must be provided for all comfort conditioned spaces, even if initial building occupancy plans are for 24-hour operation. Morning warm-up or cool-down, as applicable, must be part of the control system. Controls for the various operating conditions must include maintaining building-specific pressurization requirements (e.g., negative pressurization of laboratory spaces). An occupancy override "ON" control must be made available for occupants via the thermostats or as scheduled through the building operator.

9.2.2 Humidity Controls

Summer and winter space or zone humidity control shall be provided only on a space-by-space or zone-by-zone basis.

Indoor and outdoor humidity sensors shall be calibrated in place during system startup, and at least annually thereafter. Dew point control is preferred, because it tends to ensure more stable humidity levels. However, relative humidity sensors are acceptable, provided they have been calibrated in place and that they are co-located with dry bulb sensors (i.e., such that the BAS can convert the two signals to a dew point value for control purposes).

9.2.3 Ventilation Controls

All supply, return and exhaust ventilation systems shall be equipped with automatic and manual controls that enable shutdown of fans when ventilation is not required. To prevent introduction of outside air when ventilation is not required, these systems shall also be provided with manual, gravity-operated, or automatic control of dampers for outside air intake and exhaust or relief. Systems that circulate air shall be provided with minimum outdoor air damper position control to ensure that the minimum amount of outdoor air necessary to meet ventilation requirements (ASHRAE Standard 62.1 or project-specific criteria) is being introduced into the system. Unless otherwise required by life safety or the specific project criteria, automatic dampers shall fail open for return air and fail to a minimum setting to outside air.

Unless otherwise specified based on project requirements, automatic air control dampers must meet the ANSI/AMCA Standard 500-D. The dampers shall be opposed-blade type for modulating control, but may be opposed-blade or parallel-blade type for two-position control. Pilot positioners and operators shall be located outside of the air stream.

The BAS must allow complete monitoring, control, and set point adjustment of all points and VAV terminal unit controllers. Outside air quantity to each AHU shall be automatically controlled to meet the requirements of ASHRAE Standard 62.1.

VAV systems shall be designed with sensors and feedback control devices that sense ductwork static air pressure and velocity pressure, and that control supply fan airflow and static pressure output with variable-speed drives (ASHRAE Standard 62.1). These control systems shall have a minimum of one static pressure sensor mounted in the ductwork downstream from the fan(s) and one static pressure controller to vary fan output. Exhaust fans, supply fans, and return or relief fans shall have devices that control fan operation such that:

- Air volume output of the fan(s) is continuously monitored.
- Supply air volume to the space constantly meets, or has the capability to exceed, the fixed minimum outdoor air ventilation requirements.

9.2.4 Fire and Smoke Detection and Protection Controls

All air handling systems shall be provided with smoke and fire protection alarms and controls, in accordance with:

- NFPA 72, *National Fire Alarm and Signaling Code*.
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*.
- NFPA 101, *Life Safety Code*.
- IBC.
- GSA PBS-P100.
- Applicable state and local building codes.

Per NFPA 90A, smoke detectors are not required for fan units whose sole function is to remove air from the inside of the building to the outside of the building. All supply, return, relief and exhaust air ventilation systems shall have interlock controls that interface with the fire and smoke detection system controls. In the event of fire, these interlock controls shall either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire through the building, as required by NFPA 90A.

Special exhaust systems shall be designed to include fire and smoke safety controls required by NFPA 91. Kitchen exhaust ductwork systems shall be designed to include all fire and smoke safety controls required by NFPA 96. Engineered smoke pressurization and evacuation systems shall comply with the following:

- NFPA 72, *National Fire Alarm and Signaling Code*.
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*.
- NFPA 92B, *Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*.
- ASHRAE/Society of Fire Protection Engineers, *Principles of Smoke Management*.
- *ASHRAE Handbook—HVAC Systems and Equipment*.
- IBC.
- Applicable state and local building codes.

Special hazard protection systems that initiate an alarm shall be in accordance with the provisions in Chapter 8, Electrical Requirements, and Chapter 10, Fire Protection, within these A&E Guidelines.

9.2.5 Cooling Tower and Water-Cooled Condenser System Controls

Cooling tower controls shall conform with NFPA 214, *Standard on Water-Cooling Towers*. Design of cooling tower fans shall use variable-speed drives where feasible (or, if not feasible, two-speed motors and on/off controls) to reduce power consumption while maintaining required condenser water temperatures. Bypass valve control shall be provided, if required, to mix cooling tower water with condenser water in order to maintain the temperature of entering condenser water at the appropriate low limit. To decrease compressor energy use, condenser water temperature shall be allowed to "float," as long as the temperature remains above the lower limit required by the chiller(s). The design shall provide basin temperature-sensing devices and, if the cooling tower is operated under freezing conditions, additional heat and control system components to maintain cooling tower sump water temperatures above the freezing point. The cooling tower shall also be equipped with an overflow alarm that indicates when water is flowing through the overflow drain.

9.2.6 Simultaneous Heating and Cooling

The BAS shall be designed to minimize the use of reheat in varying humidity conditions and to support minimization of winter cooling requirements. In general, the BAS shall not be configured so as to control comfort conditions within a space by reheating or re-cooling supply air, or by concurrently operating independent heating and cooling systems to serve a common zone. Exceptions may be made, but only under the following circumstances:

- Project-specific temperature, humidity or ventilation conditions require simultaneous heating and cooling to prevent space relative humidity from rising above special, space-specific requirements.
- Project-specific building construction constraints (as established in the project requirements) prohibit installation of other types of HVAC systems.

9.2.7 Set Point Reset Controls

Systems supplying heated or cooled air to multiple zones must include controls that automatically reset supply air temperature, as required by building loads or by outdoor air temperature. Systems supplying heated and/or chilled water to comfort conditioning systems must also include controls that automatically reset supply water temperatures, as required by:

- Changes in building loads.
- Outdoor air temperature.
- Changes in return water temperature.

The BAS shall be configured to maintain compliance with the requirements for thermal comfort of occupants contained in ASHRAE Standard 55.

Summer and winter space or zone humidity and temperature control shall be provided only on a space-by-space or zone-by-zone basis, and not for the entire ventilation system (unless required to maintain specific humidity and temperature conditions, as stated in the project requirements). The BAS can provide occupants with control over their zone set points, but the range of set point adjustment should be limited to reduce the impact on feedback systems. For certain systems (e.g., UFAD systems with adjustable controls at each workstation), users may be given greater control of ventilation air delivery. The HVAC systems nighttime setback shall be controlled by a digital timing algorithm. Areas that have excessive heat gain or heat loss, or those significantly affected by solar radiation at different times of the day, shall be independently controlled.

The BAS shall also have the ability to accommodate occupancy control strategies, including:

- Infrared or ultrasonic occupancy sensors to actuate lighting.
- CO_2 sensors to actuate ventilation airflow.

In addition, an interface between the lighting occupancy sensors and the zone temperature set point can make a significant contribution to energy efficiency and should be considered during design. In a temporarily unoccupied zone, the temperature set point range can be broadened slightly to “float,” subject to the nature of the work performed in the space. The set point range would then be returned to the normal tolerance range when the zone is reoccupied (as indicated by actuation of lighting).

Supply air fans on VAV systems are typically controlled to maintain static pressure in the duct system at a given set point. For systems with DDC of individual zone boxes reporting to the BAS, the static pressure set point shall be reset based on the zone requiring the most pressure (ASHRAE Standard 90.1).

9.3 Energy Management and Conservation

HVAC systems will be provided with automatic controls that will allow systems to be operated to conserve energy. The following energy-saving controls shall be considered, if applicable to the system:

- Enthalpy-controlled economizer cycle.
- Controls to close outside air supply when the facility is unoccupied (non-laboratory areas only).
- Night setback controls.
- Outdoor temperature sensing unit that resets the supply hot water temperature in accordance with outdoor ambient temperature. (The sensing unit shall automatically shut off the heating system and the circulating pumps when the outdoor temperature reaches 65 °F, unless needed for research.)
- Controls to shut off exhaust fans.
- Reset controls for hot and cold decks or on air conditioning systems having hot and cold decks.

HVAC control algorithms shall include optimized start/stop for chillers, boilers, AHUs, and all associated equipment and feed forward controls. The optimized start/stop mode, which is controlled based on predicted weather conditions, aids in minimizing equipment run time without letting space conditions drift outside comfort set points. It accomplishes this objective by internally calculating:

- The earliest time that systems can be shut down prior to the end of occupancy hours.
- The latest time that systems can start up in the morning.

These data are then used to automatically establish the operating schedules for heating and cooling systems. Weather prediction programs shall be provided with the BAS software; these programs store historic weather data in the processor memory and use this information to anticipate peaks or part-load conditions. Economizer cycles and heat recovery equipment shall also be controlled based on the weather prediction algorithms.

The BAS shall enable building staff to monitor instantaneous and time-based trends of operational parameters (e.g., damper position, supply/return temperatures) and energy consumption. Data points related to energy consumption are those points that are monitored to ensure compliance with ASHRAE Standard 90.1. Users shall have the ability to view and trend data in the BAS from all connected equipment and systems (e.g., chillers, boilers, AHUs, cooling towers, VAV boxes, pumps). Data shall be available as instantaneous measurements and accumulated totals over a selected time period. Users shall be able to export data from the BAS into the standard database and spreadsheet formats used by the EPA and transmit data to a designated workstation(s) or website.

Refer to Section 7.8, Energy and Water Metering, within these A&E Guidelines for additional information.

9.4 Building Alarm System

The BAS shall handle building alarms for the following systems and equipment status:

- Fire alarm initiation.
- HVAC system motor alarms.
- Emergency generator running.
- Freezer and cold box temperature alarms.
- UPS system failure.
- Fume hood and biosafety cabinet alarms (critical low-flow).
- Location of activated detection, extinguishing or manual alarm device.
- Exhaust hood and ventilated cabinet failure alarms (critical low-flow).
- Exhaust systems for instrument and safety cabinet failure alarms (critical low-flow).
- Acid neutralization system alarms.
- Power failure.
- Incubator temperature alarm.
- Gas alarm.
- Sensor (gas) alarm.
- Laboratory negative pressure failure alarm.
- Sump overflow alarm.
- Cooling tower overflow alarm.
- Additional systems to be identified by the EPA on a case-by-case basis.

9.5 Maintenance Scheduling

The BAS shall include control programs that switch pumps and compressors from operating mode to standby mode on a scheduled basis. In addition, programs that provide generic preventive maintenance schedules for building systems and equipment shall be included, complete with information on which parts, tools and other resources are required to perform the necessary preventive maintenance tasks. The systems shall be configured to allow easy calibration and recalibration of all sensors and actuators installed to measure and respond to the parameters listed in Table 9-3 above.

10. Fire Protection

This chapter provides criteria for establishing minimum construction requirements at EPA-owned or leased facilities.

Unless otherwise specified in these A&E Guidelines or approved by the EPA Real Property Services Division and the EPA Safety and Sustainability Division, the following shall apply:

- Leased properties shall conform to the requirements of the local authority having jurisdiction (AHJ), the POR and the GSA lease. Property owners are responsible for keeping fire protection appurtenances, signage and markings well maintained.
- EPA-owned facilities shall conform to GSA PBS-P100, the IBC, the International Fire Code (IFC) and NFPA 101, as well as the design requirements in these A&E Guidelines. If the local fire department that provides emergency services to the EPA-owned facility has any local amendments to its fire code, these requirements shall also be met. It shall be the responsibility of the Project A/E to contact the local authority and incorporate any code issues into the design documents.
- Facilities on Department of Defense (DoD) installations may have additional requirements found in the UFC.

10.1 Emergency Vehicle Access and Fire Lanes

The design for fire department access should consider vehicular circulation, pedestrian circulation, parking, and any fire department apparatus and onsite fixed fire safety equipment (e.g., fire hydrants, fire loops, fire pumps, post-indicator valves, automatic sprinkler and standpipe system connections).

For all new construction and alterations, fire department and emergency vehicle access shall be provided and maintained in in accordance with NFPA 241, NFPA 1141, NFPA 1901, the IFC, and local codes, ordinances, and fire department requirements. This includes, but is not limited to, requirements for access roadway surface material, minimum width of fire lane(s), minimum turning radius for the largest fire department apparatus, weight of the largest fire department apparatus and minimum vertical clearance of the largest fire department apparatus. Where there is a conflict, the more stringent requirements apply.

The Project A/E and the EPA shall coordinate with the local fire marshal or other AHJ to meet all relevant requirements of local fire code pertaining to emergency vehicle access. Access of emergency vehicles shall be accounted for within the barrier system design and comply with Section 503 of the IFC and local codes.

Gates equipped with electrically controlled devices shall have an override key switch. All electrically controlled gates shall also be provided with a manual override to allow operation of the gate during power outage, and shall be designed to remain in the open position when left unattended. In addition, electrically operated gates shall be equipped with a key switch that meets local code and the AHJ's requirements. Activation of the switch shall open the gate(s) and cause them to remain in the open position until reset by emergency response personnel.

Bollards installed across entrances that emergency vehicles may use must be collapsible. Bollards shall be designed to collapse when a steady bumper force is provided by an emergency vehicle or provided with a locking hinge equipped with a Knox Box key lock or similar standardized locking arrangement. In addition, bollards shall be equipped with a manual activation mechanism that can be operated using a standard fire hydrant wrench.

If an intercom system is used at site entrances, it shall allow for emergency response personnel to communicate directly with the facility's Security or Fire Command Center.

EPA-owned properties shall have fire lane markings as follows:

- Both the inner and outer edges of the fire lane shall be marked. Where curbs are present, the top and face of the curb shall be painted red. Where no curbs are present, the edges of the fire lane shall be marked with a 4- to 6-inch solid red demarcation line. Where the demarcation line of a fire lane intersects an access roadway or parking lot aisle, the line across the intersection may be a solid or broken line.

- The words "NO PARKING – FIRE LANE" or "FIRE LANE – NO PARKING" shall appear in 4-inch white letters at 25-foot intervals on the red demarcation line along both sides of the fire lane. Where curbs are present, the words shall be on the vertical face of the curb.
- Roadways shall be marked with the words "FIRE" and "LANE." The markings shall be painted with the word "FIRE" being closest to a driver approaching such marking. Each word shall be at least 10 feet high and 20 feet wide. The distance between the word "FIRE" and the word "LANE" shall be no greater than 30 feet. The distance from the word "LANE" to the beginning of the second set of roadway markings where the word "FIRE" begins shall be no greater than 100 feet.
- Fire lane signs shall be spaced at a maximum of 50-foot intervals. All fire lane signs shall be located between 6 to 8 feet above the pavement. Signs shall be placed at each end of the fire lane. Signs shall face all oncoming traffic. Where no parking is provided between the building and the fire lane, signs shall be posted along the inner curb, building line or edge of the roadway immediately adjacent to the fire lane.

10.2 Main Firefighting Water Supply

A dependable public or private water supply capable of supplying the required flow for firefighting shall be provided for all EPA-owned and leased buildings. EPA-owned buildings shall be designed in accordance with the following requirements.

All water mains supplying fire protection systems and fire hydrants shall be treated as fire mains and installed in accordance with NFPA 24. Water mains shall have a minimum pressure rating of 150 psi. Water distribution systems shall be designed to maintain normal operating pressures of 40 psi to 100 psi (at ground level) in mains and building service lines. Where the gradient across the service area is such that multiple pressure zones are necessary to maintain the normal operating pressures, pressure-reducing valves shall be used to separate each pressure zone. Use of pressure relief and surge relief valves shall be considered, as necessary, to preclude system damage from water hammer.

When domestic water distribution systems also supply firefighting water, the system shall be capable of:

- Delivering a peak domestic flow of 2.5 times the average daily demand, plus any special demands, at a minimum residual pressure of 20 psi at ground elevation (or higher-pressure residual pressure if special conditions warrant).
- Satisfying firefighting flow requirements plus 50 percent of the average domestic requirements, plus any additional demands (e.g., process water, cooling water) that cannot be reduced during a fire.
    - Where domestic water distribution systems must serve internal fire protection systems (i.e., sprinklers or foam systems), adequate residual pressures shall be maintained for proper operation of these systems.

For buildings located in rural areas where established water supply systems for firefighting are not available, the water supply shall be obtained from a tank, reservoir or other reliable source. Any variations from the above flow requirements shall have written permission from the EPA.

10.2.1 Fire Hydrants

Except as noted below, every building shall be provided, at a minimum, with a water supply that is available for use by fire department mobile pumping apparatus. The water supply shall normally be provided by fire hydrants suitable for firefighting apparatus. The hydrants shall be supplied from a dependable public or private water main system. Alternative water supplies must comply with NFPA 1142. Other water supplies shall be available to buildings where fire protection requires them. Fire protection water does not have to meet drinking water standards.

Each fire hydrant within the distribution system must be capable of delivering 1,000 gallons per minute at a minimum residual pressure of 20 psi. Fire hydrant branches (from main to hydrant) shall be not less than 6 inches in diameter and no longer than 300 feet. A gate valve shall be installed within each fire hydrant branch to facilitate maintenance. Fire hydrants shall be installed at maximum intervals of 400 feet and not be located more than 300 feet from the buildings to be protected. Each building shall be protected by at least two hydrants.

Fire hydrants must be between 3 to 7 feet from the roadway shoulder or curb line. Barrels must be long enough to permit at least an 18-inch vertical clearance between the center of the 4.5-inch suction connection and the finished grade. The grade shall be sloped so that any surface drainage flows away from the hydrant. The suction connection shall be perpendicular to the street to allow for a straight-aligned connection to the pumper.

Fire hydrants shall be color-coded in accordance with NFPA 291, unless the local fire department has another manner to distinguish the flow characteristics of the hydrants. The hydrant number and main size shall be stenciled on the fire hydrant in contrasting color to the hydrant.

The water supply system shall provide ample water for each of the three types of fire protection water use: outside fire department hose streams from hydrants; small and large hose streams from inside-building standpipe or hose connections; and automatic sprinkler systems. The minimum requirements for each type of water use shall not be cumulative or additive and are determined as described below.

10.2.2 Fire Department Hose Streams

The hose stream required shall be determined by using the needed fire flow calculation method outlined in Section 300 of the Fire Suppression Rating Schedule of the Insurance Service Office and the local fire code authority. Fire flow testing shall be conducted in accordance with NFPA 291 and shall be performed early in the design stage. The water flow test shall be adjusted to account for diurnal fluctuations based on daily use and seasonal supply, using hydraulic gradients, computer modeling or a predetermined pressure safety factor.

Based upon the available water flow, the size of the building or the construction materials proposed for the building may be limited. The required fire flow shall be based on the fire areas of the building, not on the entire area of the building. The fire flow for the fire area requiring the greatest water flow shall be the needed fire flow for the building.

10.3 Types of Construction

Identification of construction classifications is required to meet both the local building code criteria and the criteria of EPA, GSA and NFPA standards. The various types of construction are defined in NFPA 220 and the model building codes. The construction classifications shall be indicated on design documents as applicable along with any height and area calculations.

The type of construction of an EPA building shall be the one determined to be the most suitable and economical for the occupancy classification and the height and area limitations dictated by the local building code. Height and area, including the area of any floor in the building, shall not exceed the limits set forth in the local building code.

10.3.1 Ceilings

Suspended ceilings shall not be considered part of a fire-resistive assembly in any areas. Routine building O&M requires periodic access to the space above the suspended ceiling. It has been the experience of the EPA that a rated floor-ceiling assembly is not a design that can be reasonably maintained as a fire-resistive assembly over the life of the building.

10.3.2 Mixed Occupancies

Mixed occupancies are areas in which two or more classes of occupancy coexist. As per the IBC and NFPA 101, mixed occupancies can be either non-separated or separated. In non-separated uses, the means of egress, construction, protection and other safeguards are based on the occupancy that demands the more stringent requirements. Separated uses are divided from one another by means of fire separation including fire-retardant walls, fire doors and other related openings, and fire-resistant floor and ceiling openings. Reference the IBC for specific information on mixed uses. NFPA 101 requires separated occupancies to be equipped with separate means of egress.

10.4 Classification of Occupancies

Buildings and spaces shall be classified by occupancy to determine separation requirements, types of construction and other fire safeguards. The use of a building or structure determines its occupancy or use classification. Methods of classification are presented in NFPA 101, other NFPA codes and standards that may apply to specific situations, and local building and fire prevention codes. The basis of these classifications varies with each code or standard. Some of the methods of classification are listed below.

- NFPA 101 occupancy classification is based on the use of the building or area considered. Examples are business, assembly and industrial occupancies.
- Model building code use classification is based on the use of the building or area considered. Examples are Use Group B (business), S-1 (moderate hazard storage), and F (factory and industrial) as defined by the IBC.
- NFPA 13 hazard classification is based on the degree of fire hazard represented by the use of the building or area to be protected by sprinklers. Examples are Light Hazard and Ordinary Hazard (Group 2).
- NFPA 45 laboratory classification is based on the amount of flammable and combustible liquids and liquefied flammable gases per floor area present in a laboratory unit. Examples are Class A, Class B and Class C.
- NFPA 230 construction classification is based on the type of materials stored and their burning characteristics.

Further details regarding classification of occupancy can be found in the standards referenced above, as well as from the IBC. Special design considerations are outlined in the GSA PBS-P100 for high severity occupancy in accordance with the IBC.

Occupancy classifications shall be clearly identified in design documents, construction documents, as-built/record drawings and specifications. Since occupancy classifications are specific to the respective codes and standards, all relevant occupancy classifications shall be indicated. For example, a Class B laboratory as defined by NFPA 45 could be either Use Group B (business) or H (high hazard) as defined by the IBC, and Industrial Occupancy as defined by NFPA 101. The following list could represent the occupancy classifications for a single laboratory project.

- NFPA 45—Class B Laboratory.
- NFPA 101—Industrial.
- IBC—Business.
- NFPA 13—Ordinary Hazard (Group 2), or Extra Hazard (Group 1) if flammable compressed gases.
- NFPA 10—Ordinary Hazard.

If the local building code is not based on the IBC, or there are conflicts between the local code and a model code, the discrepancy shall be brought to the attention of the EPA Project Manager for resolution.

10.5 Egress

The building subdivisions and the arrangement of exits, corridors, vestibules, lobbies, and rooms shall conform to NFPA 101, the IBC, and/or local codes, whichever is most stringent. In addition to the aforementioned codes, means of egress for laboratory facilities shall comply with the requirements set forth in NFPA 45. The facility, buildings and interior modules shall have controllable access, which should ensure a reasonably safe and secure working environment.

10.5.1 Conference Room/Conference Center/Assembly Occupant Load Factors

Rooms that are conference rooms, conference centers or places for employees to assemble shall have an occupant load calculated based upon the characteristics of the furniture that could be utilized in the room. For rooms without fixed seating, multiple arrangements of tables and chairs need to be evaluated separately for egress purposes.

10.5.2 Lighted Exit Signs

Exit signs shall not contain tritium, the radioactive form of hydrogen. If the tubes in the exit signs are severely damaged, the tritium can escape and enter the body through inhalation or an open wound, or be absorbed through the skin. Personnel should not handle damaged exit signs.

10.5.3 Photoluminescent Materials

Exit Stair Identification Signs

The EPA has specific requirements in addition to NFPA 101 for exit stair identification. They are as follows:

- Stair identification signs shall have a photoluminescent background complying with ASTM E2072, *Standard Specification for Photoluminescent (Phosphorescent) Safety Markings*.
- The signs shall be a minimum size of 18 inches by 12 inches.
- The letters designating the identification of the stair enclosure shall be a minimum of 1.5 inches in height.
- The number designating the floor level shall be a minimum of 5 inches in height and located in the center of the sign.
- All other lettering and numbers shall be a minimum of 1 inch in height.
- The directional arrow shall be a minimum of 3 inches in length.

Exit Stair Treads

The EPA has specific requirements in addition to NFPA 101 for exit stair identification. They are as follows:

- Stair treads shall incorporate a photoluminescent stripe that is either an applied coating, or a material integral with, the full width of the horizontal leading edge of each stair tread, including the horizontal leading edge of each landing nosing.
- The width of the photoluminescent stripe shall be between 1 inch and 2 inches.
- The width of the photoluminescent stripe, measured horizontally from the leading edge of the nosing, shall be consistent at all nosings.
- The photoluminescent materials used shall comply with ASTM E2072.

Exit Stair Handrails

The EPA has specific requirements in addition to NFPA 101 for exit stair handrails. They are as follows:

- Stair handrails shall incorporate a photoluminescent marking that is either an applied coating, or a material integral with, the entire length of each handrail.
- The photoluminescent handrail marking, at a minimum, shall be located at the top surface of each handrail, having a minimum width of 0.5 inches.
- The photoluminescent handrail marking shall stop at the end of each handrail. If the handrail turns a corner, the marking shall continue around the corner.
- The photoluminescent materials used shall comply with ASTM E2072.

10.6 Coatings and Interior Finishes

10.6.1 Intumescent Coatings

Intumescent coatings shall not be used to increase the fire resistance rating of any component. Use of intumescent coatings for specialized situations or applications must be approved by a Licensed Fire Protection Engineer and/or the EPA Safety and Sustainability Division. Any intumescent coating utilized for special applications must be approved or listed by a recognized testing laboratory. Coatings must be applied and maintained in accordance with the manufacturer's recommendations and the product listing.

10.6.2 Combustible Substances

Materials composed of basically combustible substances (e.g., wood, fiberboard) that have been treated with fire-retardant chemicals throughout the material (e.g., pressure impregnation), as opposed to surface treatment, may be used as interior finish subject to the following conditions:

- The treated material shall be installed in full accordance with the manufacturer's instructions.
- The treated material shall not be installed in any location where conditions exist that may reduce the effectiveness of the fire-retardant treatment (e.g., high humidity).
- The treated material is listed by UL or other nationally recognized testing laboratory.

Fire-retardant surface treatments may be used to reduce the risks associated with existing conditions, in accordance with applicable codes. Materials that will result in flame spread or smoke development ratings higher than those permitted in these A&E Guidelines shall not be used as an interior finish. Finishing materials shall conform to flame spread and smoke developed criteria requirements as set forth in the most stringent of the applicable codes.

10.7 Fire Life Safety Requirements for Specific Room Types

This section describes special, and often more stringent, fire life safety considerations that shall be followed for specific room types.

10.7.1 Telecommunications Rooms

When communications equipment is essential to the continuity of operation of the building or is otherwise critical, the communications room shall be protected by fire barrier walls. Communications installations shall meet the requirements of NFPA 76.

10.7.2 Information Technology Equipment Rooms

Except as noted below or elsewhere in these A&E Guidelines, the provisions of NFPA 75 shall be followed for electronic equipment rooms. The scope of NFPA 75 shall be used to determine applicability of this section.

- **Construction:** All operations shall be housed in a building of fire-resistant or noncombustible construction and shall be separated from other occupancies within the building by 1-hour fire-rated construction. All materials used in construction shall have a flame spread rating of 25 or less and a smoke development rating of 450 or less (Class A rating per NFPA 101). Raised floors shall be of noncombustible construction. Except for small supervisory offices directly related to the electronic equipment operations, no activity shall be located within the fire-rated enclosure. Important and vital records that have not been duplicated and stored at a different location shall be stored in a room with 2-hour fire-rated enclosure. Class 150 1-hour-or-better data storage equipment shall be provided only for vital data that have not been duplicated and that are being stored within the electronic equipment operations area.
- **Ventilation:** A separate air-conditioning system shall be provided for the electronic equipment operation area. If the system serves other areas, dampers to protect against both smoke and fire shall be provided

for the duct work at every penetration of the electronic equipment area fire separation. No other ducts shall pass though the electronic equipment areas.

- **Emergency Accessories:** Emergency lights, alarms, strobe lights and all necessary appurtenances shall be provided as required by NFPA 75. Smoke detectors shall be provided at ceilings and in raised floors and for data storage areas, in accordance with NFPA 72.
- **Fire Suppression:** Automatic wet-pipe sprinkler protection shall be provided for electronic equipment operations areas, including data storage areas, in accordance with NFPA 13. No sprinkler piping shall penetrate the shell of the room(s). To prevent accidental striking of the sprinkler and to keep the wet pipe of the sprinkler main outside the perimeter of the room(s), sprinklers in these areas shall be either (1) concealed, dry barrel, sidewall sprinklers; or (2) flexible dry sprinklers with a concealed pendant sprinkler. The sprinkler piping serving the room(s) may be valved separately, but valves shall be provided with tamper switches connected to the building fire alarm system.
- **Electrical Switches:** Emergency shutoff switches shall be provided at all exits from the electronic equipment area. These switches will allow for the disconnection of all power to the electronic equipment and air-conditioning systems. The same shutoff switch shall be connected to a sprinkler water flow device so that the power to the computer room, including the air handlers, will be shut off automatically when the sprinkler system operates. The water flow device used to disconnect power to the equipment shall be equipped with a supervised bypass switch so that maintenance testing can be conducted without disconnecting power to the computer room equipment.

10.7.3 Records Storage Facilities and Areas

Records storage facilities and areas shall comply with NFPA 232, *Standard for the Protection of Records*; the record storage and compact storage requirements of GSA PBS-P100; and the U.S. National Archives and Records Administration regulations in 36 CFR 1234.

10.7.4 Storage Cabinets for Flammable and Combustible Liquids

Cabinets for the storage of Class I, Class II, and Class IIIA liquids shall be provided in accordance with the design, construction, and storage capacity requirements stated in NFPA 30. Venting of storage cabinets is not required for fire protection purposes, but venting may be required to comply with local codes or authorities having jurisdiction. If venting is not required but desired by the program, funding for this feature shall be supplied by the local program. Non-vented cabinets shall be sealed with the bungs supplied with the cabinet or with bungs specified by the manufacturer of the cabinet.

For EPA-owned buildings, closers on cabinet doors shall meet GSA PBS-P100. Facilities on DoD installations shall meet GSA PBS-P100 and the UFC; the most stringent criteria shall apply.

10.7.5 Storage Tanks for Compressed Gases and Cryogenic Liquids

Storage tanks for compressed gases and cryogenic liquids shall comply with NFPA 55.

10.8 Automatic Fire Suppression

10.8.1 Automatic Sprinkler Protection

Automatic sprinkler protection shall be provided in all new EPA-owned or leased facilities, as required by code. All sprinkler systems shall be hydraulically calculated in accordance with NFPA 13. Facilities located on DoD installations shall follow the UFC. All design documents, including the hydraulic calculations, must be maintained at the building to facilitate future modifications of the sprinkler system.

Existing facilities shall be provided with sprinkler protection under the following circumstances:

- In major modifications to existing laboratories that use chemicals, flammable liquids or explosive materials.

- Throughout all floors of any building where EPA occupancy is 75 feet high or higher. The height shall be measured from the lowest point of fire department access to the floor level of the highest occupiable story.
- Throughout occupancies exceeding the area or height limitations allowed by the IBC.
- In all areas below grade that meet the definition of "windowless" in the IBC.
- In all areas that contain a high-severity occupancy as defined by the GSA.
- Throughout windowless buildings, windowless floors of buildings and windowless areas that exceed the allowable limits of the IBC.
- In cooling towers with more than 2,000 cubic feet of a combustible fill when the continued operation of the cooling tower is essential to the operations in the area it services; the building is totally sprinkler protected; a fire in the cooling tower could cause structural damage or other severe fire exposure to the building; or the value of the cooling tower is five or more times the cost of installing the sprinkler protection.
- In any location where the maximum fire potential of the occupancy exceeds the fire-resistance capabilities of exposed live-load-bearing structural elements (e.g., when a flammable-liquids operation is moved into a former office area).
- Throughout electronic equipment operation areas, including data storage areas.

Variances

If a variance is proposed to any of the requirements above to not include automatic sprinkler protection in an existing or a new facility, a fire analysis shall be performed to demonstrate that the facility still meets applicable codes. The provision of sprinkler protection (when not required by another code or standard) shall not be used as a basis for reducing other levels of protection provided for that facility. However, where a code or standard allows alternatives based on the provision of sprinklers, the alternatives allowed for sprinklered space may be applied.

Special protection systems supplement automatic sprinklers as described by the IBC and shall not be used as a substitute for them, except where water is not available for sprinkler protection. As used in this document, a Licensed Fire Protection Engineer shall have a valid Professional Engineering License in Fire Protection Engineering and shall meet the requirements of the Society of Fire Protection Engineers Member Grade or equivalent.

In addition to the IBC requirements, atrium sprinkler systems shall be designed as a separate sprinkler zone. In addition, a separate manual isolation valve and a separate water flow switch shall be located in an accessible location. A tamper switch shall be provided on all such valves.

The minimum flow required to meet the needs of the automatic sprinkler system shall be determined by hydraulic calculations, as required for sprinkler system designs. The water supply requirements shall include all sprinkler flow and required hose stream allowances outlined in NFPA 13.

10.8.2 Water Supply Testing

Water flow testing shall be conducted in accordance with NFPA 291. In existing buildings outfitted with a fire pump, the annual fire pump test performed by an independent contractor will suffice. All tests shall be witnessed by a representative of the EPA Safety and Sustainability Division. The water flow test shall be adjusted to account for diurnal fluctuations based on daily use and seasonal supply, using hydraulic gradients, computer modeling or a predetermined pressure safety factor.

10.8.3 Size and Zoning

The sprinkler system main shall be sized to meet the required fire flow and pressure requirements. Fire pump(s) shall be provided, if needed, and shall be installed in a separate room along with the sprinkler system main valves. Sprinkler system water flow switch arrangement shall have the same boundaries as the fire alarm system fire zones. Each sprinkler system protection zone shall be equipped with electrically supervised control valves and water flow alarm systems connected to the fire alarm system.

10.8.4 Dry Pipe

In areas subject to freezing, install dry-pipe sprinkler systems, install minimum 12-inch barrel dry type sprinklers with wet piping in heated space, provide heat in the space, and/or reroute the sprinkler piping. Heat tape shall not be used on sprinkler piping. Where the unheated area is small, it may be cost-effective to install dry type sprinklers. Antifreeze systems shall not be installed in any new construction or renovation projects.

10.8.5 Quick Response

Quick-response sprinklers must be used in new installations except where prohibited by NFPA 13.

10.9 Fire Alarm Systems

Devices that activate fire alarm systems and evacuation alarms must be completely separated from other building systems, such as environmental monitoring systems, BAS and security systems. Other features of the fire alarm system (e.g., fan control or shutdown) may be shared with these other building systems, but the performance of the fire alarm system must not be compromised and must meet the requirements stated in this subsection. In general, auxiliary functions, such as elevator recall and smoke control, are not performed by the fire alarm system, but by other mechanical or electrical systems.

The main fire alarm system shall supervise any auxiliary fire alarm control panel or sub-panel (e.g., computer room smoke detection). Activation of the main fire alarm shall also activate the audible (and visual, if applicable) devices of the auxiliary fire alarm control panel or sub-panel in the associated alarm area. The fire alarm system shall be in compliance with the most recent codes and publications and:

- GSA PBS-P100.
- ABAAS.
- EPA Safety Manual.
- IBC.
- IFC.
- State and local codes.

A fire alarm control panel shall only serve one building. The fire alarm control panels may be interconnected on a campus-wide arrangement, but an alarm shall sound only in the affected building. Continuity of business shall prevail in the unaffected buildings. A graphic annunciator with light emitting diodes (LEDs) shall be located at the main entrance to each building. Alphanumeric annunciators may be used only if an associated graphic layout with LEDs is attached.

10.9.1 Automatic Systems Input

Supervisory signals shall be transmitted under each of the following conditions:

- Operation or failure of generator.
- Operation, failure or phase reversal of electric fire pump.
- Loss of primary power to a fire alarm system, fire pump or extinguishing system.
- Malfunctioning of the fire protection system battery back-up system.
- Failure of one of the circuits/channels that carries the fire alarm signal to the remote, constantly manned Central Monitoring Station.
- Loss or too great of air pressure for dry-pipe sprinkler system.

- Low water level in pressure tanks, elevated tanks or reservoirs.
- When fire protection control valves are equipped with electronic monitoring devices, a supervisory signal shall be transmitted when the hand wheel valve is turned no more than two complete revolutions or there is 10 percent closure of the valve, whichever is less.

10.9.2 Automatic Systems Output

All fire alarm activations shall immediately activate all indicating devices, initiate all emergency control functions and transmit the alarm to the Central Monitoring Station. Pre-signal features and positive alarm sequence systems are not acceptable.

- All alarm signals or messages shall be continuous. Where public address systems are provided for the facility, there shall be provisions for making announcements from the main fire alarm panel or from an attended location where the fire alarm signal is received.
- The output of special extinguishing systems, such as those provided for kitchens, shall include the actuation of the building fire alarm system. Special detection systems shall indicate a supervisory signal at the fire alarm panel.
- For voice communications systems, only the occupants of the fire floor, the floor below and the floor above are expected to relocate or evacuate. These occupants must automatically receive that message and be notified of the emergency. Where automatic prerecorded voices are used, message arrangement and content shall be designed to fit the needs of the individual building (e.g., bilingual messages where appropriate).
- The use of visual signals to supplement the audible fire alarm system shall be provided in accordance with NFPA 72, the IBC and ABAAS.
- Every alarm reported on a building fire alarm system shall automatically actuate one of the following:
  - A transmitter listed by UL, connected to a privately operated, central-station, protective signaling system conforming to NFPA 72. The central-station facility shall be listed by UL; automatic telephone dialers shall not be used.
  - An auxiliary tripping device connected to a municipal fire alarm box to notify the local fire department, in accordance with NFPA 72.
  - A direct supervised circuit between a building and the local fire alarm headquarters or a constantly manned fire station, in accordance with NFPA 72.
  - As a last resort, an alternate method approved by the EPA Safety and Sustainability Division.

Notification of the fire department shall occur no more than 90 seconds after the initiation of an alarm. The specific location of the alarm may be determined by fire department personnel after they arrive.

10.9.3 System Features

All systems shall include the following:

- Indication of normal or abnormal conditions.
- Annunciation of alarm, supervisory or trouble conditions by zone.
- Graphic annunciation of alarm conditions by zone.
- Ring-back feature when a silence switch for audible trouble signal is provided.

High-Rise Systems Features

For high-rise buildings, the systems shall also include the following:

- Permanent record of alarm, supervisory or trouble conditions via printer.
- Initiation of an alert tone followed by a digitized voice message.
- All power supply equipment and wiring shall be installed in accordance with the requirements of NFPA 70 and NFPA 72.

10.9.4 Reliability

In accordance with and as defined in NFPA 72, the Project A/E shall indicate, by class and style, the initiating device, notification appliance and signaling line circuits, which shall define the circuit's capability to continue to operate during specified fault conditions.

10.9.5 Central Station Service

The building(s) shall be protected by local fire alarm system(s) connected to either a fire department station or a UL-listed central station service unit meeting the requirements of NFPA 72.

10.9.6 Fire Zones

Building(s) shall be subdivided into fire zones as recommended by the IBC; NFPA fire suppression, detection, and alarm codes; and state codes. Fire alarm zones and sprinkler water flow switches shall be arranged to indicate the same zones. Separate fire alarm and sprinkler zones create confusion. Properly designed sprinkler piping layouts with strategically placed water flow switches create a cohesive overlapping of zones. Graphic annunciators shall be provided at the main entrances and the security control center. These annunciators shall clearly show the outline of the buildings, the fire zones, and the alarm-initiating devices. All signal devices shall be addressable (i.e., each device shall have its own address, which shall report to monitoring devices in English for clear and quick identification of the alarm source).

10.9.7 Wire Class and Circuit Survivability

The fire alarm system initiating device circuits shall be wired Class A, Style 7; alarm-indicating circuits (visual and audible) shall be wired Class A (NFPA 72). In addition, the fire alarm system wiring shall meet the requirements of GSA PBS-P100 for fire alarm survivability. Furthermore, adjacent fire alarm audible and visible notification appliances shall be on separate circuits.

10.9.8 Emergency Power

Emergency power must be able to operate the fire alarm system in the supervisory mode for 48 hours, and to operate all alarm devices and system output signals for at least 90 minutes.

10.9.9 Carbon Monoxide Detectors

Carbon monoxide detectors and detection systems shall be allowed to be transmitted to the fire alarm system as a supervisory signal. Carbon monoxide detectors and detection systems shall be installed and maintained per NFPA 72.

10.9.10 Fire Command Center

Where required by the IBC, state or local codes, or NFPA 101, the building must have a fire command center where fire-related control panels are located. The fire command center must be located next to the main entrance and shall be separated from the rest of the building by 1-hour fire-resistive construction. If the command center cannot practically be located at the main entrance, coordinate its location with the local fire department and the EPA Safety and Sustainability Division. Fire command centers shall comply with the applicable requirements of NFPA 1 and the IBC. Fire command center layout, size, and all features provided shall be submitted to the EPA Safety and Sustainability Division and the local fire department for approval prior to construction of the center. Features provided in the command center shall be as required by NFPA 1 and the IBC.

10.10 Portable Fire Extinguishers

Portable fire extinguishers containing carbon tetrachloride or halon (chlorobromomethane) extinguishing agents shall not be used. As per the requirements of GSA PBS-P100, in office buildings protected throughout with quick response sprinklers, fire extinguishers shall only be installed in areas such as mechanical and elevator equipment areas, computer rooms, uninterruptible power supply rooms, generator rooms, kitchen areas, and special hazard areas.

Fire Extinguisher Locations

Portable fire extinguishers shall be provided in every laboratory room. It is good practice to also locate a fire extinguisher in the corridor outside the laboratory in addition to those located within the laboratory. In the other areas of the building or in non-laboratory buildings, the minimum number of fire extinguishers needed for protection shall be determined in accordance with NFPA 10.

10.11 Gaseous Fire Suppression Systems

10.11.1 Halon-1301 Fire Extinguishing Systems

Fire protection systems that contain Halon-1301 (CF_3Br, a halogenated hydrocarbon) shall not be installed in new EPA facilities. Existing systems that use Halon-1301 shall be removed from service in accordance with Title VI of the 1990 CAA Amendments. The hardware may be left in place in anticipation of an environmentally acceptable replacement. This policy applies to both fixed and portable systems. The halon recovered from systems shall be made available through the Halon Recycling Corporation (1-800-258-1283).

Refer to the EPA Environmental Management Manual for information on removal of halon systems from EPA-owned or leased facilities. Refer also to the list of acceptable halon substitutes approved under the EPA's SNAP program.

10.11.2 Carbon Dioxide Fire Extinguishing Systems

While carbon dioxide systems are allowed in normally occupied spaces, it is recommended that their use as a total flooding agent be limited to areas that are usually not occupied. Any carbon dioxide automatic extinguishing system that is to be used in usually occupied spaces must be reviewed and approved by the EPA Real Property Services Division and the EPA Safety and Sustainability Division, and must meet the design requirements of NFPA 12 and 29 CFR 1910.162(b)(5).

10.12 Kitchen Exhaust Hoods

Kitchen exhaust ductwork systems shall be designed, installed and maintained in accordance with NFPA 96 and the International Mechanical Code. Where differences are found, the most stringent requirement shall apply.

10.13 Operations and Maintenance Documents

O&M instructions and system layouts shall be posted at the control equipment or kept on file in the building maintenance engineer's office. All personnel who may be expected to inspect, test, maintain or operate fire protection apparatus shall be thoroughly trained in the functions they are expected to perform.

In addition to meeting the code requirements mentioned in the above subsections, the design shall be approved by the local authority having jurisdiction over the project.

11. Specialties

11.1 Furnishings

Environmentally preferable procurement requirements for furnishings are located in the federal Green Procurement Compilation. Wherever possible, refurbished or remanufactured furniture is recommended.

Furnishings are discussed in more detail in Volume 1 of the EPA Facilities Manual, *Space Planning and Acquisition Guidelines*.

11.2 Interior Signage Systems and Building Directory

Interior signage systems and building directories must comply with ABAAS and OSHA standards, including 29 CFR 1910.145, *Specifications for Accident Prevention Signs and Tags*. Signage also must comply with the environmentally preferable procurement requirements in the federal Green Procurement Compilation, where applicable.

11.2.1 Door Identification

Door identification shall be installed in approved locations and must comply with ABAAS Section 703. Restroom, stairway and corridor doors must be identified by the international symbol of accessibility at a height of 54 to 66 inches above the floor. Wherever possible, such identification should be mounted on the wall at the latch side of the door. Seldom-used doors to areas posing danger to the blind must have knurled or acceptable plastic abrasive-coated handles. Tactile warning indicators shall not be used to identify exit stairs. Each exit sign must be illuminated to a surface value of at least 5 footcandles by a reliable light source and be distinctive in color. Each exit sign must have the word “Exit” in plainly legible letters not less than 6 inches high, with the principal strokes of the letters in the word “Exit” not less than 0.75 inches wide.

11.2.2 Room Numbering

A room-numbering and room-naming system is required for the identification of all spaces in the facility. Signage plans shall be submitted to the EPA Project Manager for review and approval before signs are made.

11.2.3 Building Directory

The Project A/E shall propose the building directory type, style and format as part of the building design and submit those items to the EPA Project Manager for review and approval.

11.3 Laboratory Casework

Preferably, all laboratory casework and associated fume hoods required in the facility shall be the product of one manufacturer and shall be installed under the direction of that manufacturer. The laboratory casework design shall meet the functional, aesthetic, adaptable, and maintenance needs of the scientists and technicians who will be using the labs. Performance set forth herein shall establish minimum standards for design, performance and function. Products that fail to meet these standards will not be considered.

Unless otherwise noted, all surfaces shall be of stainless steel or another nonporous, durable, corrosion-resistant material. For rooms that do not require casework of metal construction, the casework materials shall be wood or approved plastic. The Project A/E shall ensure that the materials selected do not off-gas chemicals that could interfere with the research and testing that occur within laboratories within the same ventilation zone. Wood casework shall be from certified sustainable forests or recycled material. Hardware used for wood or plastic casework shall be epoxy coated. Plastic laminate or other similar facing materials, over wood or composite material, are permitted only when the laminate or surfacing material is certified by the manufacturer to be impervious to acids and other common laboratory solvents.

The laboratory casework that is subject to the above requirements shall have components, configuration, materials, finish, and performance (including performance on chemical and physical performance tests) comparable to cantilevered frame (C-frame) casework systems manufactured by Hamilton Industries and Kewaunee Scientific Equipment Corporation. Equipment manufactured by others is acceptable if the products are of equal performance and have similar appearance and construction, but only after approval by the contracting officer.

11.3.1 Shelving

Reagent shelves shall be 1-inch thick plywood, faced on both sides with acid-resistant plastic laminate, with all exposed edges edge-banded in 3-millimeter (0.125-inch) thick PVC or similar performing material.

Adjustable shelving shall be 16-gauge, channel reinforced, steel shelving and shall be interchangeable with wall-hung cabinets. Shelving standards shall be double-slotted, 30 inches in length and mounted at a height of 54 inches above the finished floor (measured to the bottom of the standard). Brackets shall be 16-gauge metal with three blade hooks and shall be screwed to each shelf.

Storage shelving for chemicals shall be fitted with a raised lip or tilted slightly backward so containers will not slip off the edge. Storage shelving for chemicals shall not be mounted significantly higher than eye level, to forestall the risk of an employee upending a container and being showered with a hazardous chemical.

11.3.2 Vented Storage Cabinets

Vented acid/base storage cabinets shall be 3-foot wide metal cabinets. The inner surfaces of the cabinet shall be factory-coated to resist acid/base fumes and spills. One adjustable shelf, at a minimum, shall be provided, depending on the cabinet size.

11.3.3 Countertops

Countertop materials will vary depending on the intended use. The Project A/E shall be responsible for evaluating the requirements of the laboratories to determine what countertop material is most suitable for each specific application. The Project A/E shall submit the proposed material(s) to the EPA Project Manager for review and approval. The material used for countertops shall also be used for back-splashes, side-splashes and services ledge covers. Countertops adjacent to sinks shall have grooved drain boards. Casework along walls shall have a 4-inch high backsplash. Countertops that are bio-based or have recycled content should be used, whenever possible.

Chemical-resistant plastic laminate countertops may be used in applications where extremely corrosive chemicals or large quantities of water are not expected to be used. Epoxy resin (water-based) countertops shall be used in laboratories or in areas where extremely corrosive chemicals or large quantities of water are being used on a routine basis. All joints shall be bonded with a highly chemical-resistant and corrosion-resistant cement having properties similar to those of the base material. Stainless steel countertops shall be used in special applications where sterile conditions are required (e.g., glassware washing areas, autoclave rooms), where there are controlled environmental temperatures (e.g., cold rooms, growth chambers), and where radioisotopes are being used.

Appendix A: Relevant Codes and Standards

As stated in Section 1.1, Overview, of these A&E Guidelines, this appendix includes a list of required regulations, codes, standards, references and guidance. This list is not all-inclusive, however, and omission from this list does not release the Project A/E or Construction Contractor from meeting established applicable regulations, codes, standards, references and guidance.

Citations of regulations, codes, standards, references and guidance within these A&E Guidelines shall be assumed to refer to the most recent edition at the time of contract award. Any publication dates specifically stated in the A&E Guidelines reflect the version in use when the A&E Guidelines were written and published. When using these A&E Guidelines, the user shall verify that the documents referenced are the most recent and have not been superseded. In cases of conflict between codes, standards or other requirements, the most stringent, technically appropriate criteria shall apply. Where it is unclear which set of requirements is applicable, consult the EPA Project Manager for direction.

A.1 Required Regulations, Codes, Standards and References

- American National Standards Institute/American Industrial Hygiene Association/American Society of Safety Professionals.
  - Z9.2, *Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems*.
  - Z9.5, *Laboratory Ventilation*.
- American National Standards Institute/American Society of Mechanical Engineers.
  - B31.1, *Power Piping*.
  - B31.3, *Process Piping*.
  - B31.9, *Building Services Piping*.
- American National Standards Institute/American Society of Safety Professionals.
  - Z9.11, *Laboratory Decommissioning*.
  - Z9.14, *Testing and Performance-Verification Methodologies for Ventilation Systems for Biosafety Level 3 (BSL-3) and Animal Biosafety Level 3 (ABSL-3) Facilities*.
- American National Standards Institute/Building Owners and Managers Association Z65.1, *Office Buildings: Standard Methods of Measurement*.
- American National Standards Institute/International Safety Equipment Association Z358.1, *American National Standard for Emergency Eyewash and Shower Equipment*.
- American Society of Civil Engineers/Structural Engineering Institute 41, *Seismic Rehabilitation of Existing Buildings*.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers.
  - Standard 55, *Thermal Environmental Conditions for Human Occupancy*.
  - Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*.
  - Standard 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings*.
  - Standard 189.1, *Standard for the Design of High-Performance Green Buildings* (select requirements as identified in these A&E Guidelines).
- Clean Air Act.

- Clean Water Act.
- Code of Federal Regulations.
- Community Environmental Response Facilitation Act.
- Energy Independence and Security Act of 2007.
- Energy Policy Acts of 1992 and 2005.
- Federal Management Regulation.
- Federal Property and Administrative Services Act.
- *Guide for the Care and Use of Laboratory Animals*.
- International Code Council.
  - International Building Code.
  - International Energy Conservation Code.
  - International Existing Building Code.
  - International Fire Code.
  - International Mechanical Code.
  - International Plumbing Code.
- National Air Duct Cleaners Association *Assessment, Cleaning, and Restoration of HVAC Systems*.
- National Fire Protection Association.
  - 1, *Fire Code*, and its mandatory referenced codes and standards.
  - 101, *Life Safety Code*, and its mandatory referenced codes and standards.
- National Historic Preservation Act.
- National Primary Drinking Water Regulations.
- NSF International/American National Standards Institute 49, *Biosafety Cabinetry Certification*.
- Resource Conservation and Recovery Act.
- Safe Drinking Water Act.
- Telecommunications Industry Association.
  - 568 Set, *Commercial Building Telecommunications Cabling Standard Set*.
  - 569, *Telecommunications Pathways and Spaces*.
  - 606, *Administration Standard for Telecommunications Infrastructure*.
  - 607, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*.
  - 942, *Telecommunications Infrastructure Standard for Data Centers*.
- U.S. Access Board *Architectural Barriers Act Accessibility Standard*.
- U.S. Council on Environmental Quality.
  - *Guidance for Federal Agencies on Sustainable Practices for Designed Landscapes* and its addendum, *Supporting the Health of Honey Bees and Other Pollinators*.
  - *Guiding Principles for Sustainable Federal Buildings*.

- U.S. Council on Environmental Quality/Advisory Council on Historic Preservation *NEPA and NHPA: A Handbook for Integrating NEPA and Section 106*.
- U.S. Department of Commerce.
  - National Institutes of Standards and Technology.
    - Handbook 135, *Life Cycle Costing Manual for the Federal Energy Management Program*.
    - *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings: ICSSC Recommended Practice 8*.
- U.S. Department of Health and Human Services.
  - Centers for Disease Control and Prevention/National Institutes of Health *Biosafety in Microbiological and Biomedical Laboratories*.
  - National Institutes of Health.
    - *Design Requirements Manual* (as applicable, for Biosafety Level 3 facilities).
    - *Public Health Service Policy on Humane Care and Use of Laboratory Animals*.
- U.S. Department of Homeland Security.
  - Interagency Security Committee policies and standards, including *The Risk Management Process for Federal Facilities* and its appendices.
  - National Earthquake Hazard Reduction Program *Recommended Seismic Provisions for New Buildings and Other Structures*.
- U.S. Environmental Protection Agency.
  - *EPA Building Commissioning Guidelines*.
  - *EPA Performance Requirements for Laboratory Fume Hoods*.
  - *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*.
- U.S. General Services Administration PBS-P100, *Facilities Standards for the Public Buildings Service* (select requirements as identified in these A&E Guidelines).
- U.S. Office of Management and Budget Circular A-94.

A.2 Additional Guidance

The following organizations and agencies provide guidance documents that shall be followed as applicable:

- Air-Conditioning, Heating, and Refrigeration Institute.
- Air Movement and Control Association.
- American Concrete Institute.
- American Conference of Governmental Industrial Hygienists.
- American Industrial Hygiene Association.
- American Institute of Architects.
- American Institute of Steel Construction.
- American Land Title Association.

- American National Standards Institute.
- American Petroleum Institute.
- American Society of Civil Engineers.
- American Society of Heating, Refrigerating and Air-Conditioning Engineers.
- American Society of Mechanical Engineers.
- American Society of Plumbing Engineers.
- American Society of Safety Professionals.
- American Society of Sanitary Engineering.
- American Veterinary Medical Association.
- American Water Works Association.
- American Welding Society.
- Associated Air Balance Council.
- Association for Assessment and Accreditation of Laboratory Animal Care.
- ASTM International.
- Building Industry Consulting Service International.
- Building Owners and Managers Association.
- Certified Ballast Manufacturers Association.
- Collaborative Technology Innovation and Video Services Group.
- Concrete Reinforcing Steel Institute.
- Construction Specifications Institute.
- Cooling Technology Institute.
- Illuminating Engineering Society.
- Institute for Laboratory Animal Research.
- Institute of Electrical and Electronics Engineers.
- International Association of Plumbing and Mechanical Officials.
- International Code Council.
- International Electrical Testing Association.
- International Laboratory Accreditation Cooperation.
- International Organization for Standardization.
- Laboratory Products Association.
- Lightning Protection Institute.
- Midwest Insulation Contractors Association.
- NACE International.
- National Electrical Manufacturers Association.

- National Electrical Testing Association.
- National Environmental Balancing Bureau.
- National Fire Protection Association.
- National Institute for Certification in Engineering Technologies.
- National Institute of Building Sciences.
- National Society of Professional Surveyors.
- NSF International.
- Plumbing and Drainage Institute.
- Post-Tensioning Institute.
- Sheet Metal and Air Conditioning Contractors' National Association.
- Society of Fire Protection Engineers.
- Structural Engineering Institute.
- Telecommunications Industry Association.
- Underwriters Laboratories.
- U.S. Department of Commerce.
  - National Institute of Standards and Technology.
  - National Oceanic and Atmospheric Administration.
- U.S. Department of Defense.
- U.S. Department of Energy.
- U.S. Department of Health and Human Services.
  - Centers for Disease Control and Prevention.
    - National Institute for Occupational Safety and Health.
  - Food and Drug Administration.
  - National Institutes of Health.
    - Office of Laboratory Animal Welfare.
- U.S. Department of Homeland Security.
  - Interagency Security Committee.
- U.S. Department of Labor.
  - Occupational Safety and Health Administration.
- U.S. Department of Transportation.
  - Federal Aviation Administration.
- U.S. Environmental Protection Agency.
- U.S. Federal Communication Commission.
- U.S. General Services Administration.

- U.S. National Archives and Records Administration.
- U.S. National Science Foundation.
- U.S. Nuclear Regulatory Commission.
- World Health Organization.

A.3 State and Local Regulations and Codes

See Section 1.1.4, Codes, Standards and References, of these A&E Guidelines for discussion on state and local laws and building codes.

Appendix B: Division 00, 01 and 02 Specifications

This appendix includes a list of Division 00, 01 and 02 specification sections that are likely to be applicable to EPA projects. The EPA Project Manager and COR will inform the Project A/E which sections are relevant to the project scope and shall be included within the project specifications. Topics in second or third tier sections may be combined into a higher-tiered section.

Some sample specification excerpts have been provided below to ensure these special aspects of EPA projects are addressed.

Division 00 – Procurement and Contracting Requirements

00 01 01 Project Title Page

00 01 03 Project Directory

00 01 07 Seals Page

00 01 10 Table of Contents

Division 01 – General Requirements

01 00 00 General Requirements

01 10 00 Summary

01 11 00 Summary of Work

01 14 00 Work Restrictions

HOURS OF WORK, WORKDAYS AND FEDERAL HOLIDAYS

Perform work, under this contract, during the normal workdays of *________ through *_______, except holidays as specified herein, and the normal work hours of *____ AM/PM to *____ AM/PM. For each occasion the Contractor intends to work on Saturdays, Sundays, or federal holidays or during hours other than those indicated above, obtain written permission from the COR, at least three (3) working days in advance.

Federal Holidays: For holidays that fall on Saturday, the federal holiday is observed on the previous Friday. For holidays that fall on Sunday, the federal holiday is observed on the following Monday. Federal holidays are listed below:

New Year's Day	January 1
Martin Luther King Jr.'s Birthday	January, third Monday
Washington's Birthday	February, third Monday
Memorial Day	May, last Monday
Independence Day	July 4
Labor Day	September, first Monday
Columbus Day	October, second Monday
Veterans Day	November 11
Thanksgiving Day	November, fourth Thursday
Christmas Day	December 25

RESTRICTED ACCESS AREAS

Certain spaces, including utility and equipment rooms and other areas used for research or other scientific activity, may have restricted access. Confirm any access restrictions with the COR prior to the start of work.

01 18 00 Project Utility Sources

01 20 00 Price and Payment Procedures

01 21 00 Allowances

01 22 00 Unit Prices

01 23 00 Alternates

01 24 00 Value Analysis

01 25 00 Substitution Procedures

If a product substitute is proposed, the Contractor must provide a detailed comparison between the specified product and the proposed substitute for EPA review and approval. Substitutes must meet all applicable regulations, codes, and requirements; all specified performance criteria; the Buy American Act; and the sustainability attributes of the originally specified product. Substitutes shall not contain toxic or hazardous materials, including, but not limited to, asbestos, urea formaldehyde, polychlorinated biphenyls, chlorinated fluorocarbons and lead.

Proposed substitutes must be compatible with other products and materials already selected. Where a proposed substitute needs to match an established sample for color, pattern or texture, the COR shall determine whether a proposed substitute matches the sample.

01 26 00 Contract Modification Procedures

01 29 00 Payment Procedures

01 30 00 Administrative Requirements

01 31 00 Project Management and Coordination

01 32 00 Construction Progress Documentation

01 33 00 Submittal Procedures

01 35 00 Special Procedures

01 35 03 Conservation (Historic) Treatment Procedures

The *_______________(project building(s) or site) is listed or eligible for listing on the National Register of Historic Places and requires special attention to the materials selected for installation and workmanship efforts, in accordance with the Secretary of Interior's Standards, to satisfactorily preserve and restore historic elements and finishes.

Upon request of the COR, submit evidence of technical competence in restoration work, including subcontractor resumes, references, and photographs of previous similar work.

01 35 13 Special Project Procedures

The handling of scientific research experiments by the Contractor is strictly prohibited without written notice and consent of the COR and EPA Laboratory Director. Existing research related materials may be moved only by authorized EPA personnel. If temporary relocation of research experiments is necessary, give written notice to the COR at least five (5) working days in advance of the time relocation is needed.

Take care to minimize fluctuations in air conditions and quality, particularly in areas containing laboratories and scientific research experiments. Humidity and temperature-controlled areas require consistency of utility operation. Notify the COR in writing if conditions are subject to fluctuations.

01 35 16 Alteration Project Procedures

01 35 26 Governmental Safety Requirements

01 35 29 Health, Safety and Emergency Response Procedures

Monitor and document the release/disturbance of any toxic or hazardous substances to ensure that exposure to the workers from airborne concentration of, or physical contact with, these substances does not exceed applicable regulatory worker health and safety exposure limits.

01 35 43 Environmental Procedures (Hazardous and Toxic Materials)

01 35 46 Construction Indoor Air Quality Management

01 35 91 Period (Historic) Treatment Procedures

01 40 00 Quality Requirements

01 41 00 Regulatory Requirements

01 42 00 References

01 43 00 Quality Assurance

01 45 00 Quality Control

01 50 00 Temporary Facilities and Controls

01 51 00 Temporary Utilities

01 52 00 Construction Facilities

01 53 00 Temporary Construction

01 54 00 Construction Aids

01 55 00 Vehicular Access and Parking

01 56 00 Temporary Barriers and Enclosures

01 56 39 Temporary Tree and Plant Protection

01 57 00 Temporary Controls

01 60 00 Product Requirements

01 61 00 Common Product Requirements

01 64 00 Government Furnished Products

01 66 00 Product Handling Requirements

01 66 13 Product Handling Requirements for Hazardous Materials

01 66 16 Product Handling Requirements for Toxic Materials

01 70 00 Execution and Closeout Requirements

01 71 00 Examination and Preparation

01 73 00 Execution

01 74 00 Cleaning and Waste Management

01 74 19 Construction Waste Management and Disposal (Waste Diversion and Materials Management)

01 75 00 Starting and Adjusting

01 76 00 Protecting Installed Construction

01 77 00 Closeout Procedures

The EPA reserves the right to occupy or install equipment in completed areas of the building prior to substantial completion, provided that such occupancy does not interfere with the completion of the work. Such partial occupancy shall not constitute acceptance of any part of the work.

01 78 00 Closeout Submittals

01 79 00 Demonstration and Training

01 80 00 Performance Requirements

01 81 00 Facility Performance Requirements

01 81 13 Sustainable Design Requirements (Guiding Principles)

01 81 16 Facility Environmental Requirements

01 81 19 Indoor Air Quality Requirements (Guiding Principles)

01 82 00 Facility Substructure Performance Requirements

01 83 00 Facility Shell Performance Requirements

01 83 13 Superstructure Performance Requirements

01 83 16 Exterior Enclosure Performance Requirements

01 83 19 Roofing Performance Requirements

01 84 00 Interiors Performance Requirements

01 84 13 Interior Construction Performance Requirements

01 84 19 Interior Finishes Performance Requirements (Guiding Principles)

01 85 00 Conveying Equipment Performance Requirements

01 86 00 Facility Services Performance Requirements

01 86 13 Fire Suppression Performance Requirements

01 86 16 Plumbing Performance Requirements

01 86 19 HVAC Performance Requirements

01 86 23 Integrated Automation Performance Requirements

01 86 26 Electrical Performance Requirements

01 87 00 Equipment and Furnishings Performance Requirements (Guiding Principles)

01 89 00 Site Construction Performance Requirements

01 90 00 Life Cycle Activities

01 91 00 Commissioning

01 91 13 General Commissioning Requirements

01 91 16 Facility Substructure Commissioning Requirements

01 91 19 Facility Shell Commissioning Requirements

01 92 00 Facility Operation

01 93 00 Facility Maintenance

01 94 00 Facility Decommissioning

Division 02 – Existing Conditions

02 00 00 Existing Conditions

02 41 13 Selective Site Demolition

02 41 16 Structure Demolition

02 41 19 Selective Demolition

02 42 00 Removal and Salvage of Construction Materials

02 42 96 Historic Removal and Dismantling

02 80 00 Facility Remediation

02 81 00 Transportation and Disposal of Hazardous Materials

02 82 00 Asbestos Remediation

02 83 00 Lead Remediation

02 84 00 Polychlorinated Biphenyls Remediation

02 87 00 Biohazard Remediation