United States Department of Agriculture
Research, Education, and Economics

ARS □ ERS □ NASS □ NIFA

Manual

Title:	ARS Facilities Design Standards
Number:	ARS-242.1
Date:	May 1st 2012
Originating Office:	Facilities Division, Facilities Engineering Branch AFM/ARS
This Replaces:	Manual and P&P 242.1 dated 7/24/2002
Distribution:	ARS Offices in Headquarters, Areas, and Locations

This Manual provides design policies and criteria to guide the design of ARS construction projects.

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1. BASIC REQUIREMENTS

1.1 BASIC GENERAL REQUIREMENTS

1.1.1 Purpose of the Manual

This Manual establishes design standards, technical criteria, and Agency policies to be applied during the programming, design, construction, alteration, and renovation of ARS buildings and facilities.

1.1.2 Design Principles/Objectives

ARS buildings shall be designed and constructed to best meet the functional, safety, and environmental needs of the programs they house.

A. Environmental and Functional Needs

1) ARS buildings shall provide an environment in which occupants can do their work with maximum efficiency at the optimum level of comfort, taking the following factors into consideration.

2) Arrangement of Space. Space relationships within buildings shall be planned to optimize the functions being performed by the occupant. Interaction areas shall be provided within the building to promote informal discussion among scientists and other support staff.

3) Access for the Disabled. Buildings shall meet the needs of individuals with physical disabilities. Design shall conform to the standards as outlined in the *Americans with Disabilities Act (ACT) and Architectural Barriers Act (ABA) Accessibility Standards* as promulgated by the United States Access Board. Information may be obtained from the following websites:
   - www.access-board.gov/ufas/
   - www.ada.gov/

4) Illumination. Natural and artificial illumination shall be sufficient to meet requirements of the tasks performed by the occupants.

5) Thermal Environment. The thermal environment shall be such as to provide safe working and healthful conditions for the occupants and proper climatic conditions for the work being performed. Provision of

flexibility and suitable control is necessary. Individual control shall be considered where appropriate.

6) Acoustical Environment. New buildings and alterations shall be planned and designed to minimize noise that disturbs occupants unduly or interferes with their ability to do their work. An adequate level of privacy shall be provided so that occupants can perform their tasks effectively with minimum outside disturbance. The level of privacy required will vary depending on the tasks involved.

7) Maintenance and Operation. Designs shall be based on user needs and maintenance capabilities and shall satisfy the functional requirements for efficient operation of the facility. Materials and projects shall be durable, easily maintained, and appropriate for the intended use.

8) Harmony with Environment. Special attention shall be paid to the arrangement of streets and public space of which the building is a part. Preferably, facilities should be readily accessible to pedestrians, near existing employment centers, and accessible to public transit. Within budgetary and site limitations, designs shall include development of well landscaped, inviting, people-oriented space. Designs should incorporate Federal, state, and local watershed and environmental management initiatives.

9) Regional Character. Buildings shall reflect the architectural character of the locale. Local building ordinances and zoning practices shall generally be followed. Use of materials and products indigenous to the locale of the project shall be given preference. Federal facilities projects shall incorporate aspects that help to strengthen the viability and livability of communities in which they are located by integrating local sustainability, transportation, renewable energy, etc. planning initiatives in the design.

10) Sustainable Design. New buildings and alterations shall be designed utilizing environmentally preferable products. To the greatest extent possible, bio-based building products that are of comparable price, proven performance, and availability will be used with other products. The project design shall incorporate Best Management Practices (BMP) for water conservation. Details of these BMP are available at FEMP's website:

http://www1.eere.energy.gov/femp/program/waterefficiency_bmp.html

B. Safety, Health and Security

1) ARS buildings shall provide an environment that is safe for occupants, and

that offers them maximum protection during emergencies or disasters.

2) Structural Adequacy. Design of buildings shall be adequate for the functions to be performed and the loads imposed by building equipment, occupants, and their activities. Soil and other geotechnical problems shall be carefully analyzed and resolved during the design process.

3) Protection against Disaster. Design shall provide minimum exposure to fire, earthquake, or natural disaster, and shall provide egress and refuge for all people, including the disabled, in an emergency.

4) Security. Buildings shall be designed to minimize security risks to persons, research animals, and property. Security must be an integral part of building and site planning, starting at the earliest phase and continuing throughout the process. Appropriate security design criteria shall be determined for each project, based on a facility-specific risk assessment and an analysis of all available information on security considerations, constraints, and tenant needs.

5) Accident Prevention Design. Design shall be the result of safety analyses and shall address unsafe conditions that cause injury, illness, or property damage.

6) Health Hazards. Materials and products with known or suspected properties that are hazardous to the health of occupants and installers shall be avoided. Only materials that are free of polychlorinated biphenyls (PCB), lead, and asbestos shall be used in ARS buildings. Volatile organic compounds (VOC) shall only be used if no other practical materials are available. If a VOC is used it must contain the lowest practicable concentration of VOCs. This includes materials such as paint, adhesives, sealers, sealants, floor tiles, etc.

7) Repair, Renovation, and Alterations. Design shall be accomplished to reduce or eliminate hazardous exposure through selection and use of materials and methods. Prior to any renovation or demolition project, the Architect-Engineer (A-E) shall identify any existing hazardous building constituents, such as asbestos or lead, etc. If lead or asbestos-containing materials are present, the design shall stipulate that the construction contractor shall be required to submit relevant management and abatement plans as part of their proposal for ARS approval prior to initiating work.

C. Economy

1) ARS buildings shall be designed at the most reasonable cost in terms of

combined initial and long-term expenditures, based on best life cycle costs, without compromising other project requirements.

2) Site Adaptation. In many, if not most instances, a site has already been selected before design begins; however, design professionals shall, where possible, have a part in the selection. The design of the building shall be sited economically and efficiently. Mitigate the heat island effect and light pollution. In site selection, prioritize:

- Building orientation to maximize energy efficiency of the building
- Locations in central business districts and rural town centers
- Sites well served by transit
- Site design elements that ensure safe and convenient pedestrian access
- Consideration of proximity to housing affordable to a wide range of Federal employees
- Adaptive reuse or renovation of buildings
- Avoiding development of sensitive land resources (such as greenfields and USDA Prime Farmland as defined in 7 U.S.C. 4201)
- Evaluation of parking management strategies

3) Efficient Utilization. The ratio of net usable area to gross area shall be as high as possible, consistent with program objectives. Space allocation for occupants shall be as low as possible consistent with General Services Administration (GSA) guidelines and the intended functions.

4) Economical Materials. Materials, products, and systems of proven dependability shall be used in the design or alteration of buildings. Materials shall be as economical as possible, in terms of combined initial and long-term cost and consistent with program objectives. Standard commercially available products shall be used to the extent possible and consistent with requirements to use biobased, recycled, and sustainable products.

5) Cost Alternatives. Alternatives shall be considered to ensure long-term, cost-effective design.

6) Maintenance, Operation, Repair, and Replacement Costs. Buildings shall be designed, and materials selected, to minimize the cost of maintenance and repair.

7) Foster Maximum Competition in Bidding. Buildings shall be designed and building materials, components, and systems incorporated into the design and specified so as to foster maximum competition among contractors and suppliers.

8) Project Administration. Projects shall be planned and scheduled to ensure effective and efficient design.

D. Conservation and Resources. Energy, natural resources, and water conservation shall be given prime consideration in the design of ARS buildings. Products, materials, and systems shall be selected with a view toward minimizing the use of nonrenewable resources. The design must emphasize the requirements for a waste management plan and recycling of non-hazardous construction materials. Divert a minimum of 50 percent of non-hazardous construction waste and demolition debris per Executive Order (EO) 13514.

E. Historical Preservation. Special sensitivity shall be shown in altering and retrofitting ARS buildings of historical significance to preserve and highlight their architectural integrity. The improvement design shall make no major impact upon the qualities which make these structures significant in accordance with the National Historic Preservation Act of 1966, as amended.

1.2 CODES AND STANDARDS

1.2.1 General

Federal Law: The Public Buildings Act of 1959, as amended by the Public Buildings Amendments of 1988, 40 U.S.C. 3312 (Public Law 100-678 and formerly section 21 of the Public Buildings Act of 1959, 40 U.S.C. 619), requires that each building constructed or altered by any Federal agency shall, to the maximum extent feasible, be in compliance with one of the nationally recognized model building codes and with other applicable nationally recognized codes. Additional requirements include compliance with State and local codes and special rules regarding State and local government consultation, review, and inspections.

1.2.2 Compliance with National Model Codes

The design shall adhere to one of the following national building codes as applicable to the project site and as further qualified in Section 1.2.3 (B) of this document.

A. International Building Code (IBC), maintained by the International Code Counsel. (www.intlcode.org)

B. NFPA 101- Life Safety Code, maintained by the National Fire Protection

Association (www.nfpa.org).

1.2.3 Compliance with Other National Codes

Each ARS building shall be constructed or altered, to the maximum extent feasible, in compliance with other applicable nationally recognized codes. These codes shall include, but are not limited to, electrical codes, fire and life safety codes, and plumbing codes. ARS has established the following policy:

A. Fire, Fire Alarm, Fire Sprinklers. For all projects, the requirements of the National Fire Protection Association (NFPA) National Fire Codes and Chapter 7 of this manual shall apply in lieu of other codes.

B. Plumbing Requirements. For all projects, the plumbing requirements of the National Standard Plumbing Code (NSPC) shall apply in lieu of other codes.

C. Electrical Requirements. For all projects, the electrical requirements of the National Electrical Code (NEC) shall apply. Refer to Chapter 6 for a list of codes.

D. Mechanical Requirements. For all projects, all national codes shall apply. Refer to Chapter 5 for a list of codes.

E. Telecommunications Requirements. For all projects, refer to FD PGM-06-001 and the ARS Telecommunications Distribution Design Guide, found at http://www.afm.ars.usda.gov/facilities/files/PGM-06-001.doc . In addition to the ARS Telecommunication Distribution Design Guide, the following Codes and Standards should be used:

1) Electronic Industry Alliance (EIA)

2) Institute of Electrical and Electronics Engineers, Inc. (IEEE)

3) American National Standards Institute (ANSI)

4) Telecommunications Industry Association (TIA)

5) Building Industry Consulting Service International (BICSI) Standards

1.2.4 Compliance with State and Local Codes

A. General. The policy of ARS is to comply with local building codes to the greatest extent possible; however, buildings built on Federal property are exempt from State and local building codes. In addition to using the applicable national model codes as minimum standard, special requirements directly related to local practices or circumstances which do not compromise the best interest of the Government shall be incorporated into project design.

During the planning process and development of associated environmental documentation for ARS new construction or renovation projects, the A-E shall consider all requirements (other than procedural requirements) of zoning laws and laws relating to landscaping, open space, minimum distance of a building from the property line, maximum height of a building, historic preservation, aesthetic qualities of a building, and other similar laws and regulations of a state or political subdivision of a state which would apply to the project if it were not constructed or altered by the Federal Government. The project design team is to fully address such laws and requirements in their planning and design documents. Any proposed deviations from such laws and regulations are to be documented, fully justified, and approved by ARS.

Local regulations shall be followed in the design of systems that have a direct impact on off-site terrain or utility systems, such as storm water run-off, erosion control, sanitary sewers and storm drains and water, gas, electrical power, communications, emergency vehicle access, roads, and bridges. Although with respect to the number of parking spaces, the requirements stated in the building program take precedence over any local zoning ordinances.

B. State and Local Government Consultation, Review, and Recommendations. For purposes of meeting the requirements of the Public Buildings Amendments of 1988 (Public Law 100-678), local and/or state officials shall be given the opportunity to review ARS projects for compliance with local requirements.

To effectively deal with local code compliance:

1) The A-E shall consult/meet with local code officials prior to schematic design to determine local requirements for the proposed building construction or alteration project and report those requirements to ARS for further consideration. These may include, but are not limited to, the review of drawings and specifications, on-site inspections, issuing permits, compliance with local regulations for site development, zoning regulations, hazardous material handling, and compatibility with local fire fighting practices. The A-E shall also inform the State and local government officials that ARS and its contractors are not authorized to pay any amount in compensation for any action taken by the State and/or local government officials in the exercise of their duties.

2) Once the local requirements are identified, the A-E can proceed with the design and develop the documents necessary to describe the project per

ARS requirements and for a potential plan review by State and local code officials. Upon request by ARS, the A-E shall formally submit design plans for a building department plan review, and shall time the submission in close coordination with the project schedule so as not to adversely affect progress of the project.

3) If local officials choose to review the project, the A-E shall establish a concise period of time in which comments can be accepted (e.g., 30 days). If local officials choose not to review the project, this shall be documented in the project file.

4) Local officials may submit only written recommendations concerning measures which should be taken in the construction or alteration of ARS buildings. The A-E shall review all recommendations made by State and local government officials for consistency with ARS Design Standards. Each recommendation shall be carefully considered and presented to ARS for approval.

5) The A-E shall then report its recommendations based on adequacy, cost, and nationally accepted practice to ARS regarding any such recommendations from state and/or local government officials; however, ARS shall have the final authority to accept or reject any of the recommendations for inclusion in the project design. All of the above project reviews by State and local officials must be completed well before construction contractors' proposals or bids are solicited for the project.

C. Site Specific Design Review Authorities, such as Zoning Boards, Historic Commissions, Design Review Boards, Public Art Commissions, etc.:

1) In general, the A-E shall follow the same procedures described above in paragraph B.

2) For projects located in and around Washington, D.C., the following institutions may have non-exclusive jurisdiction and shall be contacted for potential project review:

a. Projects within a designated Historic District shall be coordinated with the Commission of Fine Arts (CFA). For information on background, submission requirements, and review meeting calendar, go to www.cfa.gov.

b. The National Capital Planning Commission (NCPC) may also be responsible for reviewing certain design aspects. For additional information, go to www.ncpc.gov .

1.2.5 Code Review and Analysis

A. General. Code criteria shall be reviewed by each discipline to assure that the design of the project meets all applicable code requirements. The A-E is responsible for obtaining copies of all applicable codes and standards from the issuing authorities.

B. Code Edition. The current edition of each applicable code (national, state, and local, including the current accumulative supplements), in effect at the time of design contract award, shall be used throughout the project's design and construction. To ensure flexibility, it is ARS policy to make maximum use of equivalency clauses in all recognized codes.

C. Code/Criteria Analysis. The A-E shall prepare a comprehensive analysis of applicable codes/criteria/regulations that documents an investigation of the various codes described in Sections 1.2.2 thru 1.2.4, above, and ARS criteria that will govern the design of a specific project. Paragraph AParagraph-2 in the first Appendix of each of the Chapters that follow outlines the analyses that are required. These analyses should alert the Government to any conflicts in the project's design criteria so that they can be resolved early.

D. Conflict Between Codes and ARS Requirements. All conflicts between ARS requirements and either National or State/local codes, shall be resolved by designing for the most stringent requirements.

1) Any deviations/equivalency concepts proposed for use by the A-E must be submitted to the Government for approval no later than the 35 percent design stage through the Engineering Project Manager (EPM) for Facilities Division (FD) administered projects or Area Office Engineer (AOE) for Area-administered projects.

2) The request must state the deviation/equivalency concept proposed, reasons for the request, and supporting rationale.

3) The EPM or AOE will coordinate the request with the appropriate office and provide a response to the A-E.

1.3 COMPLIANCE WITH NATIONAL ENVIRONMENTAL POLICY ACT

1.3.1 The National Environmental Policy Act

The National Environmental Policy Act (NEPA) was established January 1, 1970, to ensure Federal agencies consider the potential impacts of their actions on the environment. As required under NEPA, the USDA and ARS published regulations to supplement the Council on Environmental Quality (CEQ) guidelines for NEPA implementation. The CEQ regulations appear at 40 CFR 1500-1508; USDA; USDA regulations can be found at 7 CFR 1b; and ARS regulations can be found at 7 CFR 520.

These regulations provide managers and decision-makers a means to evaluate the direct, indirect, and cumulative environmental consequences of proposed actions at the earliest possible time (i.e., before irreversible commitment of resources). They also specify how to document efforts to identify, evaluate, and quantify both the positive and negative environmental effects of proposed actions.

It is ARS policy to fully comply with the NEPA law and applicable regulations. Whenever possible, consideration should be given to avoiding or mitigating adverse environmental effects.

Within ARS, separate procedures for evaluating the environmental effects of research programs and construction projects have been established. Environmental reviews of research programs are not a design requirement and will be handled internally by ARS. Procedures for Area and Headquarters construction projects are described below. The Area Director (AD) is responsible for making and documenting all NEPA decisions. AD's shall have signatory authority on all final NEPA documentation. The AD will establish a process to ensure that analysis and preparation of NEPA documentation is made by appropriate staff having information relevant to the final determination. The specific process should be consistent with the management structure of the Area.

1.3.2 NEPA Process for Construction Projects

The AD will categorize each construction project upon the submission of a Procurement Request in the Agency's automated Integrated Acquisition System (IAS).). One of the following types of decisions must be made for each construction project:

A. Categorical exclusion -- Environmental Assessment (EA) is not required; or

B. Environmental Assessment (EA) is required – EA leading to a Finding of No Significant Impact (FONSI); or

C. Environmental Impact Statement (EIS) is required -- leading to Record of Decision (ROD).

Since each research project conducted at the facility will undergo separate NEPA consideration, only the physical impacts of the actual construction on the environment need to be addressed.

Proposed construction projects can be categorically excluded from EA or EIS requirements if the action to be taken is non-controversial and meets one of the following criteria:

1) Repair and maintenance of an existing facility, including alterations and renovations.

2) Planning, inventory, survey, data collection, and permit activities.

3) Emergency actions to protect life, property, environment; to preserve human health and safety; and to comply with legal requirements.

If the proposed action cannot be categorically excluded (for example, new construction), then, generally, an EA is prepared (i.e., the AD may decide to move directly to an EIS if the human environmental impacts of the project are significant and warrant it.) Both EAs and EISs are required to identify and analyze impacts from energy usage and alternative energy sources for proposals for new or expanded Federal facilities under the National Environmental Policy Act.

An EA is a concise public document that is prepared during the planning and design phases of a construction project. The EA includes a discussion of the need for the proposed action, alternatives to the proposed action, the environmental impacts of the proposed action and its alternatives, and a listing of agencies and persons consulted. The EA should assess the direct, indirect, and cumulative effects of the proposed project. This assessment provides the AD with the information necessary to determine whether an EIS should be prepared or if an FONSI can be made.

If the AD makes a FONSI decision, then justification explaining why the proposed action does not have a significant impact on the human environment is documented. If the EA highlights several human or environmental impacts that are known or anticipated to be controversial, then review of the proposed action must continue to an EIS.

An EIS is a detailed document presenting an evaluation and analysis of all relevant factors where a determination is made that Agency action will significantly affect the quality of the human environment. The EIS process begins with the publication of a Notice of Intent in the Federal Register. The Agency begins the scoping process to determine the issues to be addressed in the EIS. Public participation is encouraged during the scoping process through public hearings. Once concluded, a draft EIS is prepared based on the identified issues. The public is then provided a 45-day comment period for review of the draft EIS. During this time, members of the public, Federal, State, local agencies, American Indian Tribes, and other interested parties can review and comment. In addition, a copy of the draft EIS must be submitted to the EPA for review.

After the review process, the Agency responds to all comments and incorporates them into the final document. The final EIS is published in the Federal Register for a 30-day public comment period. At the end of this time, the AD makes a decision on the proposed action. To justify and explain the course of action, a ROD is published for public review.

1.3.3 List of Potential NEPA Issues for Consideration When Developing Environmental Assessment

Will proposed construction action:

A. Cause or contribute to soil erosion by wind or water?

B. Affect soil surface stability?

C. Degrade water quality in a sole source aquifer?

D. Decrease aquifer yield or affect water rights?

E. Affect aquatic life?

F. Cause or contribute flow variation in a stream or spring?

G. Degrade the aesthetic properties and/or potential uses of either ground or surface waters?

H. Affect chemical quality of ground or surface waters (pH, dissolved oxygen, nutrients, dissolved solids, pesticides, etc.)?

I. Affect physical quality of ground or surface waters (suspended solids, turbidity, color, oil, temperature, etc.)?

J. Cause odors or release odoriferous substances to air or water?

K. Release toxic substances to the air in quantities that could affect human health or safety, or environmental quality?

L. Release particulate matter to the air?

M. Change local meteorological conditions or air movement patterns?

N. Release substances for which there is a National Ambient Air Quality Standard (i.e., sulfur oxides, nitrogen oxides, carbon monoxide, lead, particulate matter, etc.)?

O. Affect undisturbed natural areas or a wild and scenic river?

P. Affect game animals or fish or their taking?

Q. Affect rare, threatened, or endangered species, or a critical habitat? (A consultation with U.S. Fish & Wildlife Service under Section 7 of the Endangered Species Act may be required).

R. Affect species balance, especially among predators?

S. Involve special hazards, such as radioactivity or electromagnetic radiation?

T. Affect or to be located in a wetland, flood plain, or the coastal zone?

U. Affect a known or potential cultural, historical, or archaeological site, district, or area? (A consultation with the State Historical Preservation Officer is required).

V. Affect local or regional systems related to:

1) Transportation?

2) Water supply?

3) Power and heating?

4) Solid waste management?

5) Sewer or storm drainage?

W. Affect local land use through effects on:

1) Flood plains or wetlands?

2) Location land use?

3) Aesthetics?

4) Access to minerals?

X. Affect socioeconomic aspects of an area including:

1) Population?

2) Housing supply or demand?

3) Employment?

4) Commercial activities?

5) Industrial activities?

6) Cultural patterns?

7) Environmental justice?

Y. Cause or contribute to unacceptable noise level?

Z. Affect public health or safety?

AA. Cause public reaction or controversy?

AB. Cause Climate Change

AC. Have impacts from energy usage or alternative energy?

1.4 PHYSICAL SECURITY DESIGN

1.4.1 General

A. Security design shall be an integral part of the planning, design, and construction. Appropriate security design criteria and standards for each project shall be determined based on a facility-specific risk assessment and an analysis of all available information on security considerations, constraints, and tenant needs.

B. Security criteria shall focus on detecting, deterring, and delaying terrorist and criminal attacks through planning, programming, design, access control, and engineering measures. The primary goal must be to save lives and prevent injury, and secondarily to protect ARS buildings, functions, and assets.

C. Project-specific security requirements shall be developed based on the standards and risk assessment methodology outlined in *Physical Security Criteria for*

Federal Facilities (PSC) which establishes a baseline set of physical security measures to be applied to all Federal facilities and provides a framework for the customization of security measures to address unique risks at a facility. The PSC will apply to all buildings and facilities in the United States occupied by Federal employees for nonmilitary activities, including existing buildings, new construction or major modernizations; facilities owned, to be purchased, or leased; stand-alone facilities, Federal campuses, and, where appropriate, individual facilities on Federal campuses; and special-use facilities. Please visit http://www.dhs.gov/ynews/releases/pr_1271098574316.shtm and www.dhs.gov/isc for further information and specific requirements.

1.4.2 Security and Risk Guidelines

A. Standards

2010/Physical Security Criteria for Federal Facilities - For Official Use Only (FOUO): Establishes a baseline set of physical security measures to be applied to all Federal facilities and provides a framework for the customization of security measures to address unique risks at a facility. These baseline measures provide comprehensive solutions in all five areas of physical security, including site, structural, facility entrance, interior, security systems, and security operations and administration.

2010/Design-Basis Threat Report -- FOUO: Creates a profile of the type, composition, and capabilities of adversaries. It is designed to correlate with the countermeasures contained in the *Physical Security Criteria for Federal Facilities* and to be easily updated as needed.

2009/Use of Physical Security Performance Measures: New Interagency Security Committees (ISC) policy requires all Federal agencies to assess and document the effectiveness of their physical security programs through performance measurement and testing. This standard provides guidance on how to establish and implement a comprehensive measurement and testing program.

2008/Facility Security Levels Determinations -- FOUO: Defines the criteria and process to be used in determining the facility security level of a Federal facility, a categorization that then serves as the basis for implementing ISC standards.

B. Project-Specific Requirements. The building's specific security requirements shall be based on a risk assessment done at the earliest stages of programming. The risk assessment shall consider, at a minimum, the risk factors, tactics, and the severity level of the risk to the building as defined in the Physical Security Criteria for Federal Facilities document.

Once the risk has been defined and quantified, funding, costs, site requirements, and other considerations or restrictions shall be factored in to develop building specific design requirements. If the desired mitigation of identified risks is not attainable, some portion of the risk may have to be accepted. One of the objectives of a risk assessment system is to achieve a responsible and prudent balance between risk and mitigation measures, considering available agency resources to implement these countermeasures.

C. A building-specific risk assessment shall consider the following factors, at a minimum.

1) Symbolic Importance: Some facilities are highly visible symbols of this country, either nationally, regionally, or locally.

2) Criticality: This measures the degree to which a building houses operations and functions critical to national or regional interests of the United States.

3) Consequence: This measures a successful attack's impact on a building's occupants, assets, and functions, as well as on the larger community

4) Threats: These are classified as either criminal or terrorist threats._ Tactics may include bombs, forced entry, chemical and biological attacks, criminal acts, etc.

D. Risk Assessment Methodology. *2009/Use of Physical Security Performance Measures*: New ISC policy requires all Federal agencies to assess and document the effectiveness of their physical security programs through performance measurement and testing. This standard provides guidance on how to establish and implement a comprehensive measurement and testing program.

The risk assessment is a major element in determining which security criteria apply to a facility. Since many building features, including structure and mechanical and electrical systems, are difficult and costly to change, risk must be carefully and thoughtfully evaluated in all its complexity. Risk assessors should have intelligence on past, current, and future threats. Projections must be made over the life of the facility - as difficult as that may be to do - because of the inflexibility of most building systems, some of which may be designed to last 30-100 years.

Risk assessors also need to consider the separate characteristics as well as the interrelatedness of building systems. Each element and system, e.g., architectural, mechanical, electrical, structural, etc., should receive its own protection level rating. Throughout the security design process, professionals from many disciplines need to consider how threats and mitigating measures applied to one element affect the rest of the facility.

1.5 METRIC DESIGN

1.5.1 Metric Conversion Act

The Metric Conversion Act of 1975 (Public Law 94-168), as amended by the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418, Section 5164),), and the Savings in Construction Act of 1996 (Public Law 104-289), including Executive Order 12770, Metric Usage in Federal Government Programs, requires Federal procurement, grant, and other business-related activities to be "metric" by September 1992, to the extent feasible.

1.5.2 Metric Policy for Construction Projects

ARS Policies and Procedures (P&P) 242.6 provides policy and guidance for implementing the metric system of measurements in procurement, grants, and construction program activities of the Agency. In construction, the policy of ARS is to implement the metric system, to the extent economically feasible, in a manner and on schedule consistent with Section 5164 of Public Law 100-418, Public Law 104-289, and Executive Order 12770 of July 25, 1991. The project team will evaluate and document the use of metric design and its economic feasibility regarding project construction cost, contractor's capabilities, material availability, and location of construction.

A. All designs for repair and maintenance, renovation, and alteration work shall be done with the measurement system in which the existing facility, system, or equipment is originally designed.

B. When specifying structures or systems of "concrete masonry" or "recessed lighting fixtures" for ARS metric construction projects, hard metric versions of these products may be specified only when: the product's application requires it to coordinate dimensionally into the 100-millimeter building module; market research demonstrates the product's availability and is sufficient to ensure competitive process; and the product's total installed cost is reasonable.

1.5.3 Design Guide for Metric Construction

The A-E shall use the current edition of the "Metric Guide for Federal Construction" (published by the National Institute of Building Sciences) and the "GSA Metric Design Guide" (published by the Public Building Services of the General Services Administration) as guidance in the design of ARS metric construction projects.

1.6 ACCESSIBILITY DESIGN

1.6.1 Architectural Barriers Act

The Architectural Barriers Act of 1968 (ABA) (Public Law 90-480), as amended, requires that Federal and Federally-funded facilities built or altered after 1968 be accessible to persons with disabilities.

1.6.2 The Americans with Disabilities Act

The Americans with Disabilities Act (ADA) P.L. 101-336 was signed into law in 1990. The ADA is an anti-discrimination statute that guarantees equal opportunity for individuals with disabilities in employment, public transportation, accommodations, State and local government services and telecommunications. The Americans with Disabilities Act Accessibility Guidelines (ADAAG) is a document that sets guidelines for accessibility in places of public accommodation and commercial facilities by individuals with disabilities.

1.6.3 Accessibility Policy

The United States Access Board is the Federal agency responsible for establishing accessibility standards for the design, construction, & alteration of Federal buildings so that they are accessible and usable by disabled individuals. The document that sets applicable standards for accessible Federal facilities is the ADA and ABA Accessibility Standards manual as promulgated by the Board. Further information may be obtained from the following websites:

- www.access-board.gov/ufas/
- www.ada.gov/

ARS is committed to providing accessible work places and environments as mandated by Public Laws. The design of ARS projects shall conform to the requirements of the United States Access Board.

1.7 ENERGY DESIGN

1.7.1 National Energy Conservation Policy Act

The National Energy Conservation Policy Act (Public Law 95-61 9), as amended by the Energy Policy Act of 2005 (PL 109-58), and the Energy Independence and Security Act of 2007, and including all applicable EOs, set out and reinforce long-standing requirements for energy conservation in Federal buildings and facilities. The ARS Policies and Procedures (P&P) 134.2, ARS Energy Water and Sustainability Policy, was established in response to these mandates and is based on a policy that fosters cost effective energy and water management practices to ensure the efficient use of energy, while maximizing the ability of the agency to accomplish its mission and maintaining the health and safety of ARS employees and visitors. Details of this plan are available at: http://www.afm.ars.usda.gov/ppweb/PDF/134-02.pdf .

1.7.2 Energy Design for New and Renovation Projects

A. New Construction and Major Renovation Projects. All new construction projects including major renovation projects (where an entire facility is to be renovated) shall be designed in accordance with the energy design standard of 10 CFR, Part 433, *Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High Rise Residential Buildings,* and 10 CFR, Part 434. *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings.*

ARS has adopted the latest edition of ASHRAE Standard 90.1, Energy Efficient Standard for Buildings Except Low-Rise Residential Buildings, published by the American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) for energy conservation. New buildings must be designed to meet the energy requirements described in ARS 242.1, Chapter 5.

B. Minor Renovation/Alteration Projects. For minor renovation/alteration work, the following standards shall apply.

1) ASHRAE Standard 100.2006 - *Energy Conservation in Existing Buildings.*

2) Refer to Chapter 5 for additional energy requirements for renovations.

1.7.3 Special Design Consideration: High Performance and Sustainable Buildings

EO 13423, *Strengthening Federal Environmental, Energy and Transportation Management*, and EO 13514 *Federal Leadership in Environmental, Energy, and Economic Performance*, require the design of high performance and sustainable federal buildings. The A-E's design, therefore, shall provide for the protection of the environment through energy and water efficiency, recycling, pollution prevention, and affirmative procurement. On January 23, 2006, USDA signed The Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU). The MOU can be found at http://www.wbdg.org/sustainableEO/mou.php. All designs for new construction shall incorporate the five guiding principles of the MOU:

1. Use integrated design and commissioning.

2. Optimize energy efficiency using measurement and verification.

3. Protect and conserve water.

4. Enhance indoor environmental quality.

5. Reduce the environmental impact of materials in Federal buildings.

See Appendix 1 for more information on the Five Guiding Principles. High Performance and Sustainable Buildings Guidance can be found at http://www.wbdg.org/pdfs/hpsb_guidance.pdf. Beginning in 2020, design all buildings to be zero-net-energy by 2030.

A. Pursuant to EO 13423, ARS is committed to conducting their environmental, transportation, and energy-related activities under the law in support of their mission in an environmentally, economically, fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

B. EO 13423 and EO 13514 require the use of biobased products in Federal buildings. ARS is committed to incorporating biobased products into Federal facilities. A biobased product is a commercial or industrial product (other than from food or feed) that utilizes biological products or renewable domestic agricultural (plant, animal, or marine) or forestry materials. Biobased products are to have procurement preference if they are comparable in price, performance, and availability to non-biobased products. Refer to the USDA Bio Preferred website at http://www.biobased.oce.usda.gov/fb4p/ for information on biobased products designated as preferred. For recycled products, see Chapter

3, paragraph 4.1. For biobased products, see Chapter, 3, paragraph 4.3.

1.7.4 Renewable Energy.

The A-E shall consider incorporating renewable energy technology in all designs where the life cycle cost of renewable energy would be effective. Renewable energy includes photovoltaic, solar thermal, biomass (wood, wood waste, refuse, and agricultural waste), wind, geothermal and low impact hydro power technologies.

1.7.5 Energy Independence and Security Act of 2007

The A-E shall conform to the requirements of the Energy Independence and Security Act of 2007 which requires agencies to:

A. Use energy efficient new and replacement lighting and bulbs;

B. Reduce fossil fuel generated energy consumption in 2010 by 55 percent, 2015 by 65 percent, 2020 by 80 percent, 2025 by 90 percent, and 2030 by 100 percent in new facilities and major renovations;

C. Use a green building certification system - LEED Silver or equivalent;

D. Provide solar hot water heaters for 30 percent of hot water demand in new buildings where cost effective;

E. Purchase appliances requiring less than 1 watt of standby power;

F. Purchase Energy Star or Federal Energy Management Program (FEMP) designated energy efficient products;

G. Provide building level advanced metering for Electricity, Natural Gas, Steam and Water where cost effective; and

H. If a fueling station is part of the project, at least one dispenser shall be for renewable fuel.

1.7.6 Greenhouse Gases

Minimize greenhouse gas (GHG) emissions including carbon dioxide (CO_2), methane (CH_4), ammonium (NH_4), hydroflourocarbons (HFCs), perfluorinated compounds (PFCs), nitrous oxide (N_2O) and Sulfur hexafluoride (SF_6). Decrease use of chemicals where it will reduce GHG emissions.

1.7.7 Integrated Pest Management

Employ a coordinated use of pest and environmental information that will prevent unacceptable levels of pest damage by the most economical methods that will protect the health of people, property, and the environment.

1.7.8 Energy Conservation Strategy Report

The A-E shall create an Energy Conservation Strategy Report for approval by ARS that describes the applicable energy conservation requirements and goals as per the regulations above. The report shall further define and analyze, including cost/benefit data, the conservation methods, opportunities and strategies for implementation on the specific project that will provide compliance with the identified energy conservation requirements. The A-E's recommendations and justifications for the selection and implementation of project-specific energy conservation methods, opportunities, and strategies shall conclude the report

1.8 VALUE ENGINEERING

1.8.1 Value Engineering (VE) Policy for Construction Projects

The policy of ARS is to utilize Value Engineering (VE) as a management tool, where appropriate, to reduce the life cycle cost of the agency's construction and acquisition programs/projects while achieving the essential functions consistent with the required performance, quality, reliability, and safety. To the extent practicable, VE shall be applied in new construction and major modernization projects and in the acquisition of supplies and services.

A. VE clauses of the FAR in Part 52, shall be incorporated in appropriate solicitations or contracts for supplies, services, A-E services, and construction projects.

B. VE studies shall be performed on new construction and major modernization projects when the estimated cost of construction is $1 million or more.

1.8.2 Value Engineering Application in Facility Construction

A. The regulatory basis for the application of VE in design and construction projects is the FAR Part 48. The standard clauses for participation of A-Es and construction contractors are in Part 52; Clause 52.248-2 addresses design, and Clause 52.248-3 deals with construction.

B. When VE is introduced early in the design of a project, the savings potential is greater than if applied later in the construction phase. If VE savings are identified, the project budget may be reduced or the money may be reallocated, if justifiable, for features that would lend greater life cycle value to the building. Also, review of the design early in the process allows a change of design direction, if appropriate, without affecting project delivery schedules.

C. In the design phase, a VE study of the design documents is performed by a team of government or contract personnel who are trained in VE techniques. The discipline and expertise of the individuals performing VE shall match that required by the project. The study evaluates design alternatives that could increase the functional value of the facility at completion while reducing construction or the operation and maintenance cost.

D. In the construction phase, the government relies on the contractor's initiative to propose a VE change in accordance with the VE incentive clause included in the contract. When the contractor submits a VE change proposal (VECP) to construction requirements, materials, or methods, the contractor shares the savings. The proposed changes are evaluated by the government and, if approved, the CO modifies the contract and makes an incentive payment to the contractor. The FAR Part 48 provides guidance for processing VECPs.

E. ARS employs the services of A-Es to perform VE services during the early stages of design for specific projects. The services include evaluation and review of design documents immediately following completion of the Conceptual (35 percent) Design Stage, conduction of VE workshop in accordance with the guidelines of the Society of American Value Engineers (SAVE), and preparation of the preliminary and final VE reports. However, if only a Conception Design is required of the A-E due to funding constraints, VE of the Conceptual Design will be deferred until full funding is secured.

1.8.3 Five Phases of VE Process During Design Phase

A. Information Phases. During this phase, the VE team gathers as much information as possible about the program requirements, project design, background, constraints, and estimated/projected costs. The team performs functional analysis of systems and subsystems to identify high cost areas. The project designer provides additional design data and participates in the initial VE team conference.

B. Speculative/Creative Phase. The team uses a group interaction process to identify alternative ideas for accomplishing the function of a system or subsystem.

C. Evaluation/Analytical Phase. The ideas generated during the speculative/creative phase are screened and evaluated by the team. The ideas showing the greatest potential for cost savings and project improvement are selected for further study.

D. Development/Recommendation Phase. The team researches the selected ideas and prepares descriptions, sketches, and life cycle cost estimates to support the VE Proposal (VEP) recommendations.

E. Report Phase. The team presents the VEPs to the government during an oral presentation at the conclusion of the workshop. Shortly after the completion of the VE workshop, a preliminary VE report, encompassing the entire VE effort, is prepared by the VE team leader and submitted to the government.

The preliminary VE report addresses and all pertinent data or information that resulted from the study. Information typically will include, but is not limited to, an executive summary, a list of items or processes examined, alternatives, functional and life cycle cost analyses, VEPs and supporting information such as a description of the difference between existing and proposed design, advantages, and disadvantages; a list and analysis of design criteria or specifications that must be changed if the VEPs are accepted by the government; and the cost and schedule impact of the VEPs if implemented by the government.

After the preliminary VE report is discussed with the project designer and the government decisions are made, the VE team will prepare a final VE report to indicate those proposals that are accepted. In ARS, the decision to accept or reject VEPs is with the Research Program Representative (RPR) after consultation with the Engineering Project Manager (EPM) and Contracting Officer (CO) for the project.

1.9 DESIGN DOCUMENTATION

1.9.1 General

The A-Es design submission shall consist of a combination of drawings, specifications, narratives, calculations, and cost estimates. The requirements listed here shall be considered minimum standards for documentation. Specific submission requirements for each discipline are contained in subsequent chapters of this Manual. Recycled paper is required. Copy paper shall be recycled, processed chlorine-free (PCF) copy paper, with 30 percent post-consumer content minimum.

1.9.2 Drawings

A. Drawing Media. All drawings shall be prepared in ink or toner on 24 inches x 36 inches or 30 inches x 42 inches, 18 lb bond paper sheets minimum. Sample cover sheets and title block sheets (in electronic format) will be provided by ARS. The A-E is responsible for providing the balance of sheets necessary for the project.

B. Lettering. Lettering on drawings must be legible when drawings are reduced to half size. Generally, lettering shall be vertical, all caps, single stroke commercial Gothic style, 1/8-inch minimum height.

C. Drawing Scales. Scales for individual drawings shall be selected to avoid overcrowding of drawing elements, and shall be appropriate for high resolution legibility when printed as half size reductions. Scales shall be clearly illustrated graphically and in text on the drawings.

D. Line Weights. When selecting line weights, important features and outlines shall be more prominently depicted than those of secondary or unrelated features.

E. Uniformity. When making alterations or additions to existing drawings, special care shall be exercised to follow the same style and size lettering, as well as other conventions on the drawing(s) in the interest of uniformity.

F. Computer-Aided Design and Drafting (CADD). CADD and BIM (Building Information Management) systems shall be utilized for project design documentation production. The computer generated drawings shall exhibit the quality standards specified above (i.e., ink pen or toner plotting, clarity, appropriate lettering size and style, hierarchal line weights, etc.). It is required that each submittal includes the design specifications and design drawings in both hard copy and electronic formats on a CD-ROM. The design specifications are to be submitted in both .DOCX (MS Word) and PDF (Portable Documents Format) format, and the design drawings shall be submitted in both AutoCAD DWG and Adobe PDF format.

G. Dimensioning. For metric projects, the millimeter shall be the only unit of measurement to appear on construction documents for building plans and details for all disciplines except civil engineering, which shall be stated in meters. However, building elevation references are stated in meters. Use of millimeters is consistent with how dimensions are specified in major codes. No dimension requires the “mm” label. On the drawings the unit symbol is eliminated and only an explanatory note such as, “*All dimensions are shown in millimeters*” or

"*All dimensions are shown in meters*" is provided. Whole numbers always indicate millimeters; decimal numbers taken to three places always indicate meters. Centimeters will not be used for dimensioning.

H. Seals. Each sheet of the construction documents must bear the seal and signature of the responsible design professional. In the case of specifications and calculations, the seal and signature shall be provided on the cover and table of contents pages only.

I. Cover Sheet. Provide code compliance certification statement for the applicable codes and standards for each discipline including the professional seal and signature. The intent is to formally recognize the responsibility for compliance.

1.9.3 Specifications

A. General. The Unified Facilities Guide Specifications (UFGS) shall be the standard specification for all ARS administered projects. The A-E may purchase a set of current UFGS specifications from the WBDG (Whole Building Design Guide) website at http://www.wbdg.org/ccb/ccb.php.

B. Format. Specifications should be produced according to the UFGS (SpecsIntact) format, which incorporates the Construction Specifications Institute (CSI) Master Format (www.csinet.org). Numbering of sections within the divisions and section format shall follow UFGS recommendations. Each page within a given section shall show the page number, total number of pages, section name, section number, project name, and government project number(s). Specifications shall be bound and include a Table of Contents. The specifications shall include instructions to offerors and Division 1, edited to coordinate with ARS requirements.

C. Editing of Specifications. It is the A-Es responsibility to edit all specifications to reflect the project design intent. Specifications must be carefully coordinated with drawings to ensure that everything shown on the drawings is specified. Specification language that is not applicable to the project shall be deleted.

1.9.4 Design Narratives and Calculations

A. Format. Typed, bound narratives should be produced for each design discipline.

B. Content. Narratives shall serve to explain the design intent and to document decisions made during the design process. Like drawings and specifications, narratives are an important permanent record of the building design. Drawings and specifications are records of WHAT systems, materials, and components the building contains; narratives should record WHY they were chosen. The narrative of each submittal may be based on the previous submittal, but it must be revised and expanded at each stage to reflect the current state of the design.

C. Calculations. Manual and/or computer-based calculations should accompany narratives where required to support technical analysis. Each set of calculations should start with a summary sheet, which shows all assumptions, references, applicable codes and standards, and lists the conclusions. Calculations should include engineering sketches as an aid to understanding by reviewers. The calculations for each submittal should be cumulative, so that the final submittal contains all calculations for the project. Calculations submitted at early stages of the project must be revised later to reflect the final design.

1.9.5 Cost Estimates

A. Cost estimates must be provided at various stages of the design process, must follow CSI Specification Division format, and shall be itemized by sections within the divisions.

B. The A-E shall follow cost trends of the work so that any possibility of a cost overrun is recognized at the early stages of design. When cost estimates exceed the project's estimated construction cost (ECC), the A-E shall immediately notify the government in writing of this problem. With such notification, the A-E shall include his recommendations for effectively providing the work within the ECC described in narrative form. The government will act on such proposals according to the evaluations made by the A-E and government personnel.

1.9.6 Coordination of Design Professionals

It is essential that an architect be a lead member of the project design team. The architect must maintain a close liaison with the government project team during each design phase of the project. Decisions regarding the location and operation of the mechanical, structural, and utility systems have a major impact on the project design. Cooperative decision making is mandatory in order to facilitate accurate determination and coordination of the design disciplines and the government's requirements.

1.10 BRIDGING DOCUMENTATION

This requirement is for the preparation of a design package to be issued to "Design/Build" contractors to request proposals. The requirements are similar to

Conceptual Design as described in paragraph A2 of the second Appendix in chapters 1 through 6 in this Manual. The design package shall be "Performance Based" (based on an end product rather than "means and methods") and meet the design objectives and program criteria as defined in the Program of Requirements (POR). The design package must be in compliance with the requirements in this Manual. The design package should include the following items as a minimum:

A. Design requirements, including the required deliverables for each design stage.

   The design shall include VE by the Design/Build firm at the first design stage.

   Provide a general description and possibly a rendering for the appearance and configuration of the building. This should also include a site plan layout. Multiple options of the building configuration may be required.

   Performance specifications, including the several pages for each specification section briefly describing the references, products, and execution. Any brand names must identify 3 potential manufacturers.

B. Provide a preliminary estimate that complies with the project budget.

   Schematic design of the interior spaces.

   Provide a description of the mechanical, electrical and plumbing (MEP) design requirements, including any assumptions regarding size of equipment, diversity factors, EPACT energy analysis, etc.

   A detailed listing of energy saving features is required.

C. Descriptions of all other requirements including structural design, civil design, utility layouts, etc.

Appendix 1A: List of Abbreviations

AAALAC	American Association for the Accreditation of Laboratory Animal Care
AABC	Associated Air Balance Council
ABA	Architectural Barriers Act
ACGIH	American Conference of Governmental Industrial Hygienist
AD	Area Director
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
A-E	Architect- Engineer-
AFM	Administrative and Financial Management
AIA	American Institutes of Architects
AGA	American Gas Association
ANSI	American National Standards Institute
AOE	Area Office Engineer
APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASTM	American Society for Testing Materials
BAS	Building Automation System
BICSI	Building Industry Consulting Service International
BIM	Building Information Modeling
BSC	Biological Safety Cabinet
BSL	Biosafety Level
CADD	Computer Aided Design and Drafting
CDC	Center for Disease Control
CEQ	Council on Environmental Quality
CFA	Commission on Fine Arts
CFR	Code of Federal Regulations
CO	Contracting Officer
CPG	Comprehensive Procurement Guidelines (EPA)
CRIS	Current Research Information System
CSI	Construction Specifications Institute
DDC	Direct Digital Control
DOE	Department of Energy

EA	Environmental Assessment
ECC	Estimated Construction Cost
EIA	Electronics Industry Association
EIS	Environmental Impact Statement
EO	Executive Order
EPACT	Energy Policy Act
EPA	Environmental Protection Agency
EPM	Engineering Project Manager
FD	Facilities Division
FCB	Facilities Contracts Branch
FEB	Facilities Engineering Branch
FEMA	Federal Emergency Management Agency
FEMP	Federal Energy Management Program
FONSI	Finding of No Significant Impact
FPMR	Federal Property Management Regulations
GFP	Ground Fault Protection
GSA	General Services Administration
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
ICSSC	Interagency Committee on Seismic Safety in Construction
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
LEED	Leadership in Energy and Environmental Design (USGBC)
MOU	Memorandum of Understanding
NC	Noise Criterion
NEBB	National Environmental Balance Bureau
NEPA	National Environmental Policy Act
NEC	National Electric Code
NEHRP	National Earthquake hazards Reduction Program
NFPA	National Fire Protection Association
NIC	Noise Isolation Class
NIH	National Institutes of Health
NRC	Noise Reduction Coefficient

NSPC	National Standard Plumbing Code
OEP	Occupant Emergency Plans
OSHA	Occupational Safety and Health Administration
P&P	Policies and Procedures
PDF	Portable Documents Format
PL	Public Law
POR	Program of Requirements
RCRA	Resource Conservation and Recovery Act
REE	Research, Education, and Economics
ROD	Record of Decision
SBC	Standard Building Code
SOW	Statement of Work
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
STC	Sound Transmission Class
TDDG	Telecommunications Distribution Design Guide
TIA	Telephone Industry Association
UFAS	Uniform Federal Accessibility Standards
UFGS	Unified Facilities Guide Specifications
UPS	Uninterruptible Power Supply
USDA	United States Department of Agriculture
USGBC	United States Green Building Council
VAV	Variable Air Volume
VOC	Volatile Organic Compounds
WBDG	Whole Building Design Guide

Appendix 1B: Sustainable Buildings

The Five Guiding Principles of High Performance Sustainable Buildings for new construction and major renovations (based on the High Performance and Sustainable Buildings Guidance at http://www.wbdg.org/pdfs/hpsb_guidance.pdf)):

Principle (1) - Use integrated design and commissioning: Employ an integrated programming and design process. Establish integrated project teams consisting of a multidisciplinary team of planners, designers, end users, construction and maintenance specialists, environmental specialists, and if applicable, knowledgeable and experienced consultants. Use integrated planning and design processes that initiate and maintain project team integration in all stages of a project from planning to final delivery. The project team should establish written performance goals for site selection, energy conservation, renewable energy, water conservation, materials selection, and indoor environmental quality, along with other comprehensive design goals. A certification system and level for green buildings should be adopted. Teams should set these goals early in the planning, programming and budgeting process and ensure that the goals are attained during design and construction. Consider all stages of the building lifecycle, including deconstruction, during the planning and design process.

Employ total building commissioning practices tailored to the size and complexity of the building and its system components in order to verify performance of building components and help ensure that design requirements are met. This should include a designated commissioning team. Include commissioning requirements in construction documents. Develop a commissioning plan and schedule. Verify the installation and performance of systems to be commissioned and provide a commissioning report.

Principle (2) - Optimize energy efficiency using measurement and verification: Establish a whole building performance target that takes into account the intended use, occupancy, operations, plug loads, other energy demands and design to earn the Energy Star®, Labs 21 or other targets for new construction and renovations. For new construction and major renovations the building must be designed to achieve energy consumption levels that are at least 30 percent below ASHRAE 90.1-2004 if life cycle cost effective compared to baseline building performance. If the additional 30 percent energy savings is not life cycle cost effective, the A-E must evaluate the cost effectiveness of alternative designs at successive decrements below 30 percent (e.g., 25 percent, 20 percent, etc.) in order to identify the most energy efficient design that is life cycle cost effective for the building; however, the building must remain compliant with ASHRAE 90.1-2004.

Meter all utilities at the building level to track and continuously optimize performance. In accordance with EPACT 2005 and the Energy Independence and Security Act of 2007, install advanced meters for electricity, steam, and natural gas. Compare the actual performance data from the first year of operation to the energy design target. Enter the data into the Energy Star® Benchmarking Tool where there is a category for the building type.

<u>Principle (3) - Protect and conserve water:</u> Employ strategies that use a minimum amount of water and return it after use undegraded in quality to the greatest extent possible. Use water-efficient landscaping and irrigation strategies, including water reuse and recycling, to reduce outdoor potable water consumption by a minimum of 50 percent over that consumed by conventional means by plant species and plant densities. Employ design and construction strategies that reduce storm water runoff and polluted site water runoff such as rain gardens.

<u>Principle (4) - Enhance indoor environmental quality:</u> Meet the current ASHRAE Standard 55-2004, Thermal Environmental Conditions for Human Occupancy, including continuous humidity control within established ranges per climate zone, and ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality. To the greatest extent possible, provide thermal comfort with personal control.

Establish and implement a moisture control strategy for controlling moisture flows and condensation to prevent building damage and bacteria, mold, and fungi contamination.

Achieve a minimum daylight factor of two percent excluding all direct sunlight penetration, in 75 percent of all space occupied for critical visual tasks. Provide automatic dimming controls or accessible manual lighting controls and appropriate glare control. Integrate natural and artificial light.

Specify materials and products with low pollutant emissions, including adhesives, sealants, paints, carpet systems and furnishings. Avoid products containing formaldehyde or VOCs. Products containing PCBs, asbestos, or lead, shall not be used.

Follow the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Indoor Air Quality Guidelines for Occupied Buildings under Construction, 1995. After construction and prior to occupancy, conduct a minimum 72-hour flush out with maximum outdoor air consistent with achieving relative humidity no greater than 60 percent. After occupancy, continue to flush out as necessary to minimize exposure to contaminants from new building materials. When appropriate, provide high performance windows and natural ventilation. Monitor air quality. Protect air intakes from contaminants.

Minimize propagation and transmission of noise or vibration in occupied spaces. Provide sound absorbing materials and isolation.

Control odors and contaminants.

Provide a healthy and productive work environment.

Provide entrance walk off mats/grating to minimize introduction of dirt into buildings, thus reducing the use of cleaning chemicals.

Principle (5) - Reduce the environmental impact of materials: Select and use products that meet or exceed Environmental Protection Agency (EPA) recycled content recommendations or products with recycled content. Select and use products that meet or exceed USDA biobased content recommendations or products made from rapidly renewable resources and sustainable wood products.

During the project planning stage, identify local recycling and salvage operations that could process site-related waste. Program the design to recycle or salvage the maximum amount of construction, demolition and land clearing waste, excluding soil, where markets or onsite recycling opportunities exist.

Eliminate the use of ozone depleting compounds during and after construction where alternative environmentally preferable products are available, taking into account life cycle impacts. Minimize the use of hazardous materials and dispose of them properly. Reduce the use of chemicals and toxic materials and purchase lower risk chemicals and toxic materials from top priority list.

2. SITE PLANNING AND LANDSCAPE DESIGN

2.1 GENERAL

2.1.1 Scope

This chapter provides general objectives, considerations, and procedures for site planning and landscape design. For new construction, planning and design shall be for a predetermined site identified to the A-E by ARS. It may also be assumed by the A-E that detailed studies of the requirements of the project, its employees, its visitors, and facilities to be included in the site plan, have been determined during the programming phase.

2.1.2 Objectives

A. Site Potential. Full advantage shall be taken of existing site and landscaping potential by preserving the site's natural features and topography to the greatest extent possible.

B. Relationship of Elements. A proper and harmonious relationship shall be established between elements on a common site, and between the site and the surrounding environment. This may include sensitivity to adjoining land developments, particularly residential.

C. Functionality and Efficiency. Provide a site plan and landscape design that is economical to construct, functionally efficient, and easy to maintain.

D. Energy Conservation. The site plan and landscaping scheme shall contribute to the energy efficiency of the project through use of natural site features, planting, etc.

E. Accessibility. Select materials and design landscaping features to allow unrestricted use by individuals with physical disabilities and to provide required access for emergency vehicles per local code. The A-Es design shall maximize the use of cost-effective environmentally sound landscaping practices to reduce adverse impacts to the natural environment, prevent pollution and potential future liabilities at ARS facilities.

F. Security. Effective site planning and landscape design can enhance the security of a facility and eliminate the need for some engineering solutions. Security considerations shall be an integral part of all site planning, perimeter definition, lighting, and landscape decisions.

G. Greening the Government. Pursuant to EO 13423: *Strengthening Federal Environmental, Energy, and Transportation Management*, and EO 13514: Federal Leadership in Environmental, Energy, and Economic Performance , the A-Es design shall maximize the use of cost effective environmentally sound landscaping practices to reduce adverse impacts to the natural environment, prevent pollution and potential future liabilities at ARS facilities.

2.1.3 Codes and Standards

A. General. The design shall comply with the requirements of the codes and standards applicable to the site design. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the design and construction of the project. See Chapter 1: *Basic Requirements* for complete discussion of codes and other special requirements.

B. Code Review, Analysis, and Waiver Process. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that tasks accomplished during design, meet code requirements. All deviations from code/ARS requirements and any equivalency concepts proposed for use must be identified by the A-E and submitted to the government for approval no later than the 35 percent design stage. See section 1.2.5 for requirements.

2.1.4 Site and Landscape Design Submissions and Coordination

A. General. The A-E shall submit site and landscape design concepts, drawings, sketches, calculations, specifications, planting schedules, etc. at various stages throughout the design process as outlined in the A-E contract. (Refer to section 1.8, *Design Documentation* and Appendix 2A, *Site Design Submission Requirements*.) Projects with a footprint of 5,000 SF or greater must have a storm water plan that preserves the predevelopment hydrology. See EPA's Technical Guidance for EISA Section 438 Storm Water Management at http://www.epa.gov/greeningepa/documents/epa_swm_guidance.pdf.

B. Coordination Checklist. To insure inter-discipline and intra discipline coordination, a review checklist is provided in Appendix 2B, *Site Design Coordination Checklist*. The A-E shall make sure that all of these items, and others that pertain to good project coordination, are reviewed and addressed before submission of the documents to ARS.

C. Survey Report. If a survey is part of the scope of work for the project, see

Appendix 2C, *Site Survey Report,* for information requirement.

2.2 SITE SECURITY DESIGN

2.2.1 General

A. From the earliest programming stages, security considerations shall be an integral part of site planning, perimeter definition, lighting, signage, and landscaping decisions. Site and landscape design can help protect a building - particularly by keeping threats away, by incorporating Crime Prevention Through Environmental Design (CPTED) principles, and by decreasing the need for costly building engineering solutions to safety concerns.

<u>Note</u>: For further information on CPTED, see publications by the National Institute of Law Enforcement and Criminal Justice. See also Crowe, Timothy D. Crime Prevention Through Environmental Design. National Crime Prevention Institute (1991).

B. Appropriate site security design criteria and standards for a project shall be determined based on project-specific risk assessment done in accordance with the methodology outlined in "Physical Security Criteria for Federal Facilities" (See also section 1.4, *Security Design*).

2.2.2 Site and Landscape Security Design Considerations

A. <u>Vehicular Control</u>. Blast pressures from an exploding vehicle bomb decrease rapidly with distance from the explosion. When a vehicle bomb is identified as a threat, consideration must be given to how the site design can offer maximum protection to the building, or whether site constraints require design modifications to the structure of the building itself. Consider the following design strategy to mitigate blast effects.

1) Maintain as much distance as possible between a vehicle bomb and the facility.

2) Consider using various types and designs of buffers and barriers such as walls, fences, trenches, ponds and water basins, planting trees, and street furniture.

3) Design site circulation to prevent high speed approaches by vehicles.

4) Offset vehicle entrances as necessary from the direction of a vehicle's

approach to force a reduction in speed.

B. Site Lighting. Provide necessary lighting for security and cameras. The following are examples of effective site lighting levels: at vehicular and pedestrian entrances (15 horizontal maintained foot candles), for a perimeter, vehicular, and pedestrian circulation areas (five horizontal maintained foot candles). In most circumstances, perimeter lighting should be continuous and on both sides of the perimeter barriers, with minimal hot and cold spots and sufficient to support closed-circuit television (CCTV) and other surveillance. However, for safety reasons and/or for issues related to camera technology, lower levels may be desirable. Other codes or standards may restrict site lighting levels.

C. Site Signage. Include appropriate signage to reduce confusion. Confusion over site circulation, parking, and entrance locations can contribute to a loss of site security. Signs shall be provided at the site and at entrances. There shall be on-site directional, parking, and cautionary signs for visitors, employees, service vehicles, and pedestrians. Unless required by other standards, signs shall generally not be provided that identify sensitive areas.

D. Landscaping. Use design elements to enhance security. Landscape and hardscape design elements that are attractive and welcoming can enhance security. For example, plants can deter unwanted entry; ponds and fountains can block vehicle access; and site grading can also limit access. Avoid landscaping that permits concealment of criminals or obstructs the view of security personnel and Closed Caption Television (CCTV) in accordance with accepted Prevention Through Environmental Design (PTED) principles.

2.3 SITE DESIGN ELEMENTS

2.3.1 Physical Character of the Site

To achieve the objectives of ARSs vision for site planning, the designer must analyze the physical character of the site, the surrounding area, and develop a design that both respects and reinforces the individual character of the site considering the following:

A. Topography. The topography shall form a strong influence on design of the project site. On large project sites of open campus like development, every effort shall be extended to blend the development with existing contours. For projects within urban areas where site area is limited, the topography within and surrounding the site is equally important.

B. Natural Features. Natural site features such as existing trees, ground forms, and water shall be preserved and utilized to the maximum extent possible. Use native plants and water-efficient landscaping practices to the fullest extent possible. Refer also to the guidance issued by the Office of the Federal Environmental Executive (August 1995) which provides guidance for the Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds.

C. Undesirable Conditions that Surround the Site. Hazards and nuisances adjacent to the project site must be considered when developing the site plan. Adverse effects of excessive noise, odors, smoke, dust, etc., must be alleviated to the extent possible by proper orientation of the structures, grading, planting screens, and protective buffer strips.

D. Pursuant to EO 11988, Floodplain Management, and EO 11990, Wetlands Protection and Coastal Zone Management Act of 1972, ARS is required to avoid direct or indirect support of floodplain development and new construction in wetlands wherever there is a practicable alternative. When there is no practicable alternative and if the site is located in a floodplain, wetland, or could be exposed to flood hazards, this fact shall be stated on the working drawings. If so, occupied spaces and mechanical and electrical components shall not be located below the anticipated high water level.

2.3.2 Grading and Drainage

Grading schemes shall consider the following:

A. Reduce, control and treat surface runoff quickly, effectively, and efficiently. Rain gardens should be considered.

B. Preservation of the character of the natural terrain by minimum disturbance of existing ground forms.

C. Balancing of cut and fill.

D. Avoidance of steps in sidewalks.

E. Meet ground level of existing trees to be saved, or plan for tree wells as a part of the overall site design concept.

F. The minimum desirable slope for turf areas shall be not less than 1.5 percent. Maximum slope for turf areas shall not exceed one foot rise in three feet of run.

G. Minimum slope for parking and terrace areas shall be not less than 1.5 percent or more than 7 percent.

H. Proposed contours must meet existing grades at the property line or contract limit lines in smooth flowing curves.

I. Banks with slopes in excess of one foot of rise in three feet of run are too steep for mowing. A vine or shrub type ground cover shall be installed to ensure slope stabilization and reduce maintenance. If a design results in slopes of two to one or steeper, a retaining wall or revetment shall be provided.

J. Surface drainage shall be directed to drainage structure inlets within the site limits. Wherever possible, use rain gardens, minimizing impervious surfaces, and other strategies to minimize runoff. See 2.1.4.A.

2.3.3 Building Orientation

Orientation of structures on the site should take full advantage of sunlight, prevailing breezes, trees and vegetation, topography, and other natural features that would reduce construction costs and annual maintenance and energy expenditure.

2.3.4 Pedestrian and Vehicular Circulation

Pedestrian and vehicular traffic patterns shall be direct, convenient, safe, and allow for accessibility by individuals with physical disabilities. Pedestrian and vehicular traffic shall be separated to the extent possible. Access for emergency vehicles shall be provided. Provide for bicycles and access to public transportation where available.

2.4 LANDSCAPE DESIGN

2.4.1 General Principles

A. The landscape design shall be an integral component of the total project environment, and shall respect and preserve its existing natural attributes.

B. The landscape maintenance capability of a building’s management, or designated services contract, shall be a major consideration in the amount and complexity of the landscape design.

C. The design shall be kept simple in form but of sufficient quantity to create the mass effect of the design concept.

D. The use of hardy, drought tolerant, and native plants that will thrive in the climate hardiness zone of the site is mandatory.

E. Living plants have set habits of growth, texture, form, and color. These habits must be fully understood to avoid over planting, excessive maintenance, and conflict with other plants and structures.

F. The screening of objectionable views and the visual separation of functional elements is desirable; however, visibility and easy accessibility shall be provided for fire department connections.

G. Use of deciduous planting adjacent to west and south facing walls shall be encouraged for those climates with seasonal change.

H. Areas within the project boundaries, except those clearly intended to be modified by development, shall be preserved in their existing condition, or so improved that they will be compatible with both the new construction and the surrounding landscape.

I. Consider using small container plants.

J. Sustainable landscaping approaches such as xeriscaping and rain gardens are encouraged.

K. Landscape irrigation shall be minimized and highly efficient, even when using non-potable water. Water reuse strategies including grey water shall be considered.

2.4.2 Planting in Public Spaces

The agency has no authority to expend funds to plant trees or shrubs in areas not owned by the Federal government. If a city has a master plan for street tree planting, the project landscape architect shall coordinate with the city plan. The project plan shall then be submitted to the city for inclusion in its next street improvement project. However, many city codes require that street tree planting must be included in all building projects. Local codes should be followed using the type of tree specified on the street tree plan.

2.4.3 Planting Within or Above Portions of Buildings

Planting within or above portions of buildings poses special problems in the selection of plant material and the provisions to maintain the planting. Planting around air exhaust openings and over utility tunnels shall be avoided whenever possible. High winds and extreme temperature changes require added maintenance for plants within, or on, buildings.

2.5 SITE PLANNING/LANDSCAPE DESIGN PROCESSES

2.5.1 General

Site planning and landscape design, like the other design processes, demand that several tasks be performed and several plans shall be produced in order to develop a responsive, effective design.

2.5.2 Coordination of Design Professionals

A. In any project that includes a substantial site area development, it is essential that a landscape architect be a member of the project design team. The landscape architect must maintain a close liaison during each design phase of the project. Decisions regarding the location (underground and above ground) and operation of the mechanical, structural, and utility systems have a major impact on the site plan and landscaping. Cooperative decisions as to how and where they can best be accommodated are mandatory. In order to become acquainted with the area and its surroundings, the designer shall make frequent visits to the site, local nurseries, and similar facilities during the stages of site plan development. This will facilitate accurate determination of the proposed plan's adaptability to the site.

B. If landscape design drawings are required, a registered landscape architect shall prepare the landscape plans.

2.5.3 Site Surveys

Before preparing project site studies, a site survey shall be performed to obtain comprehensive information on existing site and landscape conditions. New construction sites shall be evaluated for the presence of radon. Where radon is present, design of facilities shall include appropriate measures to keep radon concentration below the EPA recommended action level. Refer to Appendix 2C, *Site Survey Report* for information requirement. Contact the USDA Radiation Safety Division for information on conducting radon site surveys.

2.5.4 Site Analysis

After the site surveys have been completed, a thorough analysis of existing site and landscaping conditions shall be developed as part of the design concept phase.

A. This analysis shall include consideration of the following site conditions: topography, views and vistas, natural lighting opportunities, traffic patterns (pedestrian and vehicular), noise, permanent site features, planting, climate, solar orientation, wind conditions, environmental and historical preservation impacts, and land ownership status, including potential impacts to existing right-of-ways, easements, etc.

B. Site analysis shall also include the evaluation of the geography for radon. Where radon presence is likely, special features for radon mitigation in the initial construction design must be considered.

Appendix 2A: Site Design Submission Requirements

2A-1. 15 Percent Site Design (Concepts) Submittal

A. General. This submittal stage is required on the more complex projects and/or where architectural design elements are required to obtain coordinated interior design development or development of exterior design considerations.

B. Site Survey. If a survey is part of the scope of work for the project, see Appendix 2C, *Site Survey Report* for requirements.

C. Drawings.

1) Site location plan showing the site relative to location of city center, major landmarks, major parking facilities, major roads, and airport etc.

2) Existing site plans (at least one block around the site) describing: site boundaries, approximate topography, existing buildings, setbacks and easements, climatic conditions, location of on-site and off-site utilities natural landscape, and pedestrian and vehicular circulation. Include direction of traffic on adjoining streets.

3) Site plans for each design scheme showing: building location and massing, building expansion potential, and parking and service areas.

D. Narrative (in "Executive Summary" format)

1) Site statements describing:

a) Existing site features

b) Climatic conditions

c) A topography and drainage patterns

d) Any existing erosion conditions

e) Wetlands and locations of flood plains

f) Surrounding buildings (style, scale)

g) Circulation patterns around the site

h) Site access

i) Noise/visual considerations

j) Local zoning restrictions

k) Hazardous waste

l) Pollution

m) Potential archeological artifacts

n) Historic preservation considerations, if applicable

2) Aerial site photographs, showing contiguous areas

3) All existing site utilities

4) Description of site and landscape design concept

a) Circulation

b) Parking

c) Paving

d) Landscape design

e) Irrigation, if any

f) Utility distribution and collection systems

g) Method for storm water detention or retention

h) Landscape maintenance concept

i) Fire protection, water supplies, fire hydrants, and fire apparatus access roads

j) Accessibility paths for the physically disabled

k) Public transportation and bicycle access

2A-2 Conceptual Design Submittal

A. Design Analysis

1) Listing of applicable codes

2) Site security considerations

3) Environmental considerations and permitting requirements

4) Responses to the 15 percent Review Comments

B. Drawings and Specifications

1) Site plan showing:

a) All buildings, roads, walks, parking, and other paved areas (including type of pavement).

b) Accessible route from parking areas and from public streets to main facility entrance.

c) Fire apparatus and fire lanes.

2) Grading and drainage plan showing site grading and storm drainage inlets, including storm water detention features.

3) Site utility plan showing sizes and locations of all utility lines, such as domestic and fire protection water supply lines, sanitary sewer lines, steam/condensate lines, and chilled water supply and return lines, if applicable.

4) A landscape design plan showing general areas of planting, paving, site furniture, and water features, etc.

5) Irrigation plan, if applicable.

6) List of Specifications sections to be used.

7) A narrative description of design intent, environmental considerations,

permits, grading plan, utilities description and tie-ins, special road(s) requirements, and any site-specific special requirements that should be considered when the next design phase resumes.

2A-3 50 Percent Site Design Submittal

A. Design Analysis

1) Revisions from the 35 percent submittal

2) Narrative Description of Site/Landscape systems

3) Description of site security measures

4) Description of energy conservation measures

5) Site storm drainage combined with building storm drainage, and sanitary sewer calculations

6) Storm water detention calculations, if applicable

7) Parking calculations, if applicable

8) Dewatering calculations

9) Pipe sizing calculations for water and sewer pipes

10) Responses to the 35 percent Review Comments

B. Drawings and Specifications.

1) Marked up specifications

2) Preliminary schedules

3) Demolition plans, if required

4) A site plan

a) Location of all buildings, roads, walks, accessible routes from parking and public streets to building entrance, parking and other paved areas, and planted areas.

b) Limits of construction

c) Locations and sizes of fire protection water supply lines, fire hydrants, fire apparatus access roads, and fire lanes

d) Location of flood plains and wetlands

5) Grading and a drainage plan, showing:

a) Existing and new contours

b) Spot elevations at all entrances and elsewhere as necessary

c) Elevations for walls, ramps, terraces, plazas and parking lots

d) All surface drainage structures

e) Water retention and conservation

6) Site utility's plan showing all utilities, including inlets, manholes, clean-outs, and invert elevations.

7) Planting plans, showing:

a) Building outline, circulation, parking and major utility runs

b) Size and location of existing vegetation to be preserved (include protection measures during construction)

c) Location of all new plant material (identify function, such as a windbreak or visual screen where appropriate)

d) Erosion control

8) Planting schedules, showing quantity of plants, botanical names, planted size and final size.

9) Irrigation plan, if applicable. Include schematic of irrigation control system.

10) Planting and construction details, profiles, sections, and notes as necessary

to fully describe design intent.

11) Construction phasing, if part of a project.

12) Potential archeological artifacts.

2A-4 95 Percent Site Design Submittal

A. Design Analysis.

1) Any revisions from the 50 percent submittal

2) Narrative Description of HVAC systems

3) Responses to the 50 percent Review Comments

B. Drawings and Specifications

Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

2A-5 100 Percent Site Design Submittal

A. Design Analysis.

1) Complete Design Analysis incorporating the final calculations, narrative, equipment selections, and review comments, etc.

2) Responses to the 95 percent Review Comments

B. Drawings and Specifications

Complete drawing and specification packages suitable to “Issue for Bidding and Construction.”

Appendix 2B: Site Design Coordination Checklist

2B-1. General

This checklist enumerates some of the interfaces between interdisciplinary disciplines that require close coordination.

A. Piping and other utility locations and inverts at building penetrations coordinated with mechanical, electrical, and foundation drawings.

B. Electrical service coordinated with electrical drawings.

C. Interference of utilities with underground electrical runs checked.

D. Interference between planting and utilities checked.

E. Elevations of entrances and building footprint coordinated with architectural drawings.

F. Required foundations and reinforcement shown for all free standing and retaining walls.

G. Connections to foundation drainage coordinated.

H. Sub-surface drainage shown.

I. Location of underground storage tanks shown.

J. Construction of underground storage tanks detailed.

L. Setback distances checked. Verify that property line dimensions on survey or civil site plans match architectural.

M. Paved primary and secondary points of access.

N. Verify that the locations of flag poles, dumpster pads, generator pads, transformers, cooling towers, vaults, and landscaping have been coordinated with other site design disciplines.

O. Verify and correct landscaping conflicts, such as trees with parking lot lights or underground utilities.

Appendix 2C: Site Survey Report

2C-1. General

The criteria listed here are not absolute. They shall be modified by the civil engineer to suit the particular conditions of the project. All surveys shall be prepared and sealed by a surveyor licensed in the state where the project is located.

2C-2. Information Requirements

Surveys shall contain the following information:

A. Locations of all permanent features within limits of work, such as buildings, structures, fences, walls, concrete slabs and foundations, aboveground tanks, cooling towers, transformers, sidewalks, steps, power and light poles, traffic control devices, manholes, fire hydrants, valves, culverts, headwalls, catch basins or inlets, property corner markers, benchmarks, etc.

B. Location of all adjacent and abounding roads or streets and street curbs within limits of work, including driveways and entrances. Type of surfacing and limits shall be shown. For public streets, right-of-way widths and center lines shall also be shown.

C. Location of all trees, shrubs, and other plants within limits of work shall be indicated. For trees, caliper size shall be shown; dead trees shall be indicated.

D. Location of all overhead telephone and power lines within the limits of work and their related easements.

E. Based on existing records, location of underground utilities, such as gas, water, steam, chilled water, electric power, sanitary, storm, combined sewers, telephone, etc., shall be shown. Sizes of pipes (I.D.), invert elevations, inlet or manhole rim elevations shall be indicated. Where appropriate, information shall be verified in the field.

F. Based on existing records, indicate the location of underground storage tanks or other subsurface structures.

G. Topography field criteria shall include such items as contour intervals plotted on a grid system appropriate to the scale of the survey. Elevations at top and bottom of ditches and any abrupt changes in the grade. Periodic top-of-curb and gutter elevations, as well as street centerline elevations. Elevations at all permanent features within the limits of work. Ground floor elevations for all existing buildings.

H. Bearings and distances for all property lines within the limits of work.

I. Official datums upon which elevations are based and the benchmark on, or adjacent to, the site to be used as a starting point.

J. Official datums upon which horizontal control points are based.

K. If there are not already two benchmarks on the site, establish two permanent benchmarks.

L. Elevations of key datum points for all building structures and improvements directly adjacent the project site.

M. Delineate location of any wetlands or flood plains, underground streams or water sources.

N. Presence of radon in accordance with Departmental Regulation 1650-3. (Contact the USDA Radiation Safety Division for information on conducting radon site surveys.)

3. ARCHITECTURE

3.1 GENERAL

3.1.1 Scope

This chapter provides general objectives, considerations, and procedures for the architectural design of ARS buildings and related structures.

3.1.2 Codes and Standards

A. General. The design shall comply with the local and national requirements of the codes and standards that apply to the project design. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the project's design and construction. See Chapter 1: *Basic Requirements* for complete discussion of codes and other special requirements.

B. Code Review, Analysis, and Waiver Process. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that tasks accomplished during design meet code requirements. All deviations from code/ARS requirements and any equivalency concepts proposed for use must be identified by the A-E and submitted to the government for approval no later than the 35 percent design stage. See Section 1.2.5 for requirements.

3.1.3 Architectural Design Submissions and Coordination

A. General. The A-E shall submit architectural design concepts, drawings, sketches, calculations, specifications, etc. at various stages throughout the design process as outlined in the A-E contract. (Refer to section 1.9, *Design Documentation* and Appendix 3A, *Architectural Design Submission Requirements*.)

B. Coordination Checklist. To insure inter-discipline and intra discipline coordination, a review checklist is provided in Appendix 3B, *Architectural Design Coordination Checklist*. The A-E shall make sure that all of these items, and others that pertain to good project coordination, are reviewed and addressed before submission of the documents to ARS.

3.1.4 Safety and Health

Materials and products with known or suspected properties that are hazardous to the health of occupants and installers, shall be avoided. Only materials that are PCB, lead or asbestos free and contain the lowest available levels of VOCs, shall be used in

RS buildings. This includes materials such as paint, adhesives, sealers, sealants, floor tiles, etc.

3.1.5 Accessibility

Public Law 90-480 requires that Federal buildings, including site work, be designed to ensure that individuals with physical disabilities will have ready access to, and use of, such buildings. ARS requires compliance with the United States Access Board standards.

3.2 ARCHITECTURAL SECURITY DESIGN

3.2.1 General

A. Appropriate architectural security design criteria and standards for a project shall be determined based on project-specific risk assessment done in accordance with the methodology outlined in the *Physical Security Criteria for Federal Facilities for New Federal Office Buildings and Major Modernization Projects*. (See also section 1.4, *Security Design*)

B. This section focuses on using interior planning to safeguard occupants and critical building systems. The location of functions away from high risk areas can reduce vulnerability and the consequences of various tactics. The careful selection of materials can improve building performance and enhance the Occupant Emergency Plan (OEP).

3.2.2 Architecture and Interior Design Considerations

A. <u>Planning</u>

1) <u>Office Locations</u>. Locate vulnerable offices out of public view. Offices of vulnerable officials shall be placed or glazed so that the occupant cannot be seen from an uncontrolled public area such as a street. Whenever possible, these offices shall face courtyards, internal sites, or controlled areas. If this is not possible, suitable obscuring glazing or window treatment shall be provided.

2) <u>Mixed Occupancies</u>. Separate high and low-risk tenants. When possible, high-risk tenants shall not be housed with low-risk tenants. If they are housed together, publicly accessible areas shall be separated from high-risk tenants.

3) <u>Public Toilets and Service Areas</u>. Do not place public toilets and service

areas in unsecured locations. Public toilets, service spaces, or access to vertical circulation systems shall not be located in any non secure areas, including the queuing area before screening at the public entrance.

4) Loading Docks and Shipping and Receiving Areas. Separate loading docks and shipping and receiving, from utilities. Protecting utility systems and/or locating them away from vulnerable areas helps assure that services will provide life safety and operations support after an attack.

   Loading docks and receiving and shipping areas shall be separated from utility rooms, utility mains, and service entrances including electrical, telephone/data, fire detection/alarm systems, fire suppression water mains, cooling and heating mains, etc. Loading docks shall be located so that vehicles will not be driven into or parked under the building.

5) Stairwells. Locate emergency stairwells away from high-risk areas. Stairwells required for emergency egress should be designed to support the OEP. Specify related requirements.

   Stairwells required for emergency egress shall be located as remotely as possible from areas where blast events might occur. Wherever possible, stairs should not discharge into lobbies, parking, or loading areas.

6) Mail room. Locate mail room away from critical components. The basic strategy is to detect delivered bombs before they explode. Space may need to be provided for equipment to examine incoming packages and for special containers. In some areas, an off-site location may be cost effective, or several buildings may share one mail room.

   The mail room shall be located away from facility main entrances, areas containing critical services, utilities, distribution systems, and important assets. In addition, the mail room shall be located at the perimeter of the building with an outside wall or window designed for pressure relief. It shall have adequate space for explosive disposal containers. An area near the loading dock may be a preferred mail room location.

B. Interior Construction

1) Lobby Doors and Partitions. Security procedures and OEPs will have a major impact on lobby design. Identify whether or not access control and screening are required, the level of protection, and the location. Concepts such as self enclosed screening systems at the lobby result in a different lobby design than screening stations within the building and impact other building systems including egress, queuing, HVAC, and fire protection.

2) Critical Building Components. Assuming that the building has structurally survived a bomb blast, evacuation and rescue are the most important concerns. The goal is to increase the likelihood that emergency systems will remain operational during a disaster. Separate the following critical building components from high-risk areas. One obvious strategy to avoid the cost of hardening is to locate these systems away from attack locations such as main entrances, vehicle circulation, parking, or maintenance areas.

a) Emergency generator including fuel systems, day tank, fire sprinkler, and water supply

b) Normal fuel storage

c) Main switchgear

d) Telephone distribution and main switchgear

e) Fire pumps

f) Building control centers

g) UPS systems controlling critical functions

h) Main refrigeration systems if critical to building operation

i) Elevator machinery and controls

j) Shafts for stairs, elevators, and utilities

k) Critical distribution feeders for emergency power

C. Exterior Entrances

The entrance design must balance aesthetics, security risks, and operational considerations. One strategy is to consider co-locating public and employee entrances. Entrances should be designed to avoid significant queuing.

1) Equipment Space. Public and employee entrances shall include space for possible future installation of access control and screening equipment.

2) Entrance Co-location. Combine public and employee entrances.

3) Garage and Vehicle Service Entrances. All garage or service area entrances for government controlled or employees permitted vehicles that are not otherwise protected by site perimeter barriers, shall be protected by devices capable of arresting a vehicle of the designated threat size at the designated speed.

D. Additional Features

1) Areas of Potential Concealment. To reduce the potential for concealment of devices before screening points, avoid installing features such as trash receptacles and mail boxes that can be used to hide devices. If mail or express boxes are used, the size of the openings shall be restricted to prohibit insertion of packages.

2) Roof Access. Design locking systems to limit roof access to authorized personnel.

3.2.3 Parking Security

Parking restrictions help keep threats away from a building. In urban settings, however, curbside or underground parking is often necessary and/or difficult to control. Mitigating the risks associated with parking requires creative design and planning measures, including parking restrictions, perimeter buffer zones, barriers, structural hardening, and other architectural and engineering solutions.

A. Parking

1) Parking on Adjacent Streets. Restrict adjacent street parking. Parking is often permitted in curb lanes with a sidewalk between the curb lane and the building. Where distance from the building to the nearest curb provides an insufficient setback, and compensating design measures do not sufficiently protect the building from the assessed threat, parking in the curb lane shall be restricted as follows:

a) Allow unrestricted parking.

b) Allow government owned and key employee parking only.

c) Use the lane for stand-off. Use structural features to prevent parking.

2) Parking on Adjacent Properties. Maintain prescribed distance between parked cars and facility. The recommended minimum setback distance between the building and parked vehicles range from 5 ft to 100 ft

depending on the protection level desired for the project. Adjacent public parking should be directed to more distant or better protected areas, segregated from employee parking and away from the facility.

B. Parking Facilities

1) Natural Surveillance. Design parking facilities to enhance natural surveillance. For all stand-alone above ground parking facilities, maximizing visibility across as well as into and out of the parking facility shall be a key design principle.

Pedestrian paths should be planned to concentrate activity to the extent possible. For example, bringing all pedestrians through one portal rather than allowing them to disperse to numerous access points improves the ability to see and be seen by other users. Likewise, limiting vehicular entry/exits to a minimum number of locations is beneficial. Long span construction and high ceilings create an effect of openness and aid in lighting the facility. Shear walls should be avoided, especially near turning bays and pedestrian travel paths. Where shear walls are required, large holes in shear walls can help to improve visibility. Openness to the exterior should be maximized.

It is also important to eliminate dead-end parking areas as well as nooks and crannies.

Landscaping should be done judiciously so as not to provide hiding places. It is desirable to hold planting away from the facility to permit observation of intruders.

2) Stair Towers and Elevators

a) Parking facilities shall have open stair and tower and elevator lobbies. Stair tower and elevator lobby design shall be as open as code permits. The ideal solution is a stair and/or elevator waiting area totally open to the exterior and/or the parking areas. Designs that ensure that people using these areas can be easily seen - and can see out - should be encouraged. If a stair must be enclosed for code or weather protection purposes, glass walls will deter both personal injury attacks and various types of vandalism. Potential hiding places below stairs should be closed off. Nooks and crannies should be avoided.

b) Elevator cabs should have glass backs whenever possible. Elevator lobbies should be well lit and visible to both patrons in the parking areas and to the public out on the street. When enclosure is required, such as in underground parking garages, an automatic fire door, or for a larger opening, a rolling fire shutter with an access door can be employed so that the area is wide open during normal use. Either the door or shutter will be closed by a smoke detector when needed instead of a fire-rated door that remains closed all the time.

3) Perimeter Access Control

a) Consider alternatives to fencing. Security screening or fencing may be provided at points of low activity to discourage anyone from entering the facility on foot while still maintaining openness and natural surveillance.

b) Use fencing, grills, or doors to close access when necessary. A system of fencing, grills, doors, etc. should be designed to completely close down access to the entire facility in unattended hours, or in some cases, all hours. Any ground level pedestrian exits that open into non secure areas should be emergency exits only and fitted with panic bar hardware for exiting movement only.

4) Surface Finishes and Signage. Provide parking facilities with clear signage and light surface finishes. Interior walls shall be painted a light color (i.e., white or light blue) to improve illumination. Signage shall be clear to avoid confusion and direct users to their destination efficiently. If an escort service is available, signs should inform users.

5) Lighting. Parking facilities shall have adequate lighting levels. Lighting levels shall comply with the following table:

[(From Chrest Anthony P. Smith Mary S.. and Bhuyan. Sam. Parking Structures: Planning. Design Construction. Maintenance and Repair. 2nd edition. Chapman and Hall. (1 996).]

Maintained Illumination Levels (Foot-candles)				
	Low	Low/Med	Medium	Higher
Horizontal illumination at the pavement, minimum:				
Covered parking areas	1.25	1.50	1.75	2.00
Roof and surface parking areas	0.25	0.50	0.75	1.00
Stairwells elevator lobbies	2.5	3.5	4.5	5.5
Uniformity ratios (average: minimum)	4:1	4:1	4:1	4:1
Uniformity ratios (maximum: minimum	20:1	20:1	20:1	20:1
Vertical illumination 5 feet above the pavement, minimum:				
Covered parking areas	0.625	0.75	0.875	1
Roof and surface parking areas	0.125	0.25	0.375	0.5
Stairwells, elevator lobbies	1.25	1.75	2.25	2.75

The lighting level standards recommended by the Illuminations Engineering Society of North America (IESNA) Subcommittee on Off-Roadway Facilities are the lowest acceptable lighting levels for any parking facility. The above table adjusts the lighting levels according to the protection level. A point by point analysis should be done in accordance with the IESNA standards.

6) Emergency Communications: Parking facilities shall be provided with emergency duress stations. Emergency intercom/duress buttons or assistance stations should be placed on structure columns, fences, other posts, and/or freestanding pedestals and brightly marked with striping or paint visible in low light. If CCTV coverage is available, automatic activation of corresponding cameras should be provided, as well as dedicated communications with security or law enforcement stations. It is helpful to include flashing lights that can rapidly pinpoint the location of the calling station for the response force, especially in very large parking structures. It should only be possible to reset a station that has been activated at the station with a security key. It should not be possible to

reset the station from any monitoring site. A station should be within 50 feet of reach.

7) CCTV

a) Parking facilities shall be provided with CCTV cameras at entry and exit ramps. Color CCTV cameras with recording capability and pan/zoom/tilt drivers, if warranted, should be placed at entrance and exit vehicle ramps. Auto scanning units are not recommended.

b) Fixed mount, fixed lens, and color or monochrome cameras should be placed on at least one side of regular use and emergency exit doors connecting to the building or leading outside. In order for these cameras to capture scenes of violations, time delayed electronic locking should be provided at doors if permitted by governing code authorities. Without features such as time delayed unlocking or video motion detection, these cameras may be ineffective.

3.3 SPACE REQUIREMENTS

3.3.1 Scope

Space requirements for a project shall be in compliance with applicable Federal Property Management Regulations (FPMR) as contained in the Program of Requirements (POR). It is the responsibility of the designer to adhere to the space requirements as contained in the POR and to design a project that can be constructed within the time and budget constraints.

3.3.2 Building Area Calculations

These shall be defined and computed in accordance with the American Institute of Architects' (AIA) Handbook of Professional Practice, Document D101.

3.3.3 Building Efficiency

The ratio of net to gross area shall be established in the project POR. Spaces shall be sized to support the intended function without wasted footage. Use AIA Architect's Handbook of Professional Practice Document D101 for calculating building efficiency ratios.

3.4 SPECIAL DESIGN CONSIDERATIONS

3.4.1 Incorporation of Recycled-Content Materials

The Resource Conservation and Recovery Act (RCRA) requires agencies to buy recycled-content products designated by EPA. EO 13423 and the Sustainable High Performance Buildings Memorandum of Understanding (MOU) require the use of recycled-content products. ARS is committed to maximizing the use of recycled and recycled-content materials specified in the construction of Federal building projects. The greatest opportunity to implement these requirements is in the selection of architectural materials. The most common building products incorporating recycled materials currently available on the market are:

A. Fiberboard
B. Laminated paperboard
C. Insulation
D. Carpet
E. Cement
F. Concrete
G. Paint
H. Resilient Flooring

The EPA Comprehensive Procurement Guidelines (CPG) provides extensive information on the designated products containing recycled materials for purchase and use by Federal agencies and their contractors.

Information on specifying and purchasing recycled-content products can be found on the internet at http://www.epa.gov/cpg.

3.4.2 Incorporation of Biobased Products

EO 13423 - *Strengthening Federal Environmental, Energy, and Transportation Management*, and Executive Order 13514 - *Federal Leadership in Environmental, Energy, and Economic Performance*, requires the use of biobased products in Federal buildings. ARS is committed to incorporating biobased products into Federal facilities. A biobased product is a commercial or industrial product (other than from food or feed) that is composed in whole or in significant part, of biological products, renewable domestic agricultural (including plant, animal, and marine materials), or forestry materials. Designated biobased products are to have procurement preference if they are comparable in cost, quality, and availability to non-biobased products. If there is a choice between a recycled product and an equivalent product, the recycled product should be used. Domestic includes other designated countries. Refer to the USDA Bio Preferred website at http://www.biopreferred.gov for information on biobased products designated as preferred.

3.4.3 Acoustics

A. General. ARS has adopted the following standards to ensure adequate acoustics in buildings.

B. Parameters used in Acoustic Design. The following parameters are used to establish acoustical standards for ARS buildings.

1) Ambient Noise Level. This parameter refers to the level of noise within a space. Generally, the lower the level of ambient noise the more comfortable inhabitants will feel. On the other hand, mechanical sound is sometimes introduced into a space to mask background noise and/or raise the level of speech privacy. Ambient noise level is quantified by Noise Criterion (NC) Curves, published in ASHRAE Handbook of Fundamentals.

2) Noise Isolation. This parameter refers to the amount of noise transmitted through the perimeter of a space. The better the sound barrier, the higher its Sound Transmission Class (STC).

3) Noise Isolation Class. This is a classification established by the American Society for Testing and Materials (ASTM) E-336 for determining noise isolation between existing building spaces. A modification of the rating, Speech Privacy Noise Isolation Class (NIC), is used to rate ceiling tile and freestanding space dividers in open plan office space.

4) Reverberation Control. Reverberation defines the amount and direction of sound reflected from a given material. A harder surface produces a reflected noise level. Soft surfaces absorb sound waves and reduce the ambient noise level. The ability of a given material to absorb sound is expressed by its Noise Reduction Coefficient (NRC)

C. Design Criteria for Building Spaces. The most effective way to control noise propagation in buildings is to provide buffers between noisy and quiet areas. Buffers can be unoccupied space, shafts, filing or archive areas.

1) Class A Spaces: These are critical, noise sensitive spaces. The category includes auditoria. The acoustical treatment of these spaces must be designed by a qualified acoustical consultant or specialist. Technical criteria and design variables should be established by an acoustical specialist based on an analysis of the user’s needs.

2) Class B1 Spaces: This category describes spaces where meetings take

place on a regular basis, including conference rooms and training rooms.

a) The design ambient noise levels must not exceed NC 30. Air supply and return systems should be equipped with sound traps or insulated ductwork to meet this criterion.

b) Sound isolation at partitions enclosing Class B1 space is a minimum STC of 45. Doors must be gasketed.

c) Acoustical ceilings must have a minimum of NRC of 0.55 if the space is carpeted or 0.65 if not carpeted. Background masking should not be used.

3) <u>Class B2 Spaces</u>: This category consists of spaces where people are likely to speak in a higher than normal tone of voice and spaces where concentrations of noisy equipment are located, including laboratories (with fume hoods), dining areas, Automated Data Processing (ADP) areas, computer equipment rooms, and rooms housing high speed copiers.

a) The design ambient noise levels must not exceed NC 50. Noise measurements for laboratory space with fume hoods shall be taken with all the fume hoods operating at 18” sash height and with hood sashes closed. For laboratories without hoods, noise measurements shall be taken with a maximum airflow, ie, in maximum cooling mode.

b) Sound isolation at partitions enclosing class B2 space must be a minimum STC of 45. Doors must be gasketed.

c) Acoustical ceilings must have minimum NRC of 0.55 if the space is carpeted or 0.65 if not carpeted. If background sound masking is used, the NRC criteria do not apply.

4) <u>Class C1 Spaces</u>: Enclosed general office space falls in this category.

a) The design ambient noise levels must not exceed class NC 35.

b) Partition and ceiling assemblies must have a minimum STC of 40. Partitions should terminate at the underside of the ceiling. Floors should be carpeted, unless unusual circumstances exist.

c) Acoustical ceiling units must have a minimum NRC of 0.55 if the space is carpeted or 0.65 if not carpeted. This does not apply to spaces with background masking systems.

5) Class C2 Spaces: This category describes open plan spaces.

   a) The design ambient noise levels must not exceed NC 35.

   b) Noise isolation must meet the requirements of at least NIC 20.

   c) Acoustical ceiling units must have a minimum NRC of 0.55 if the space is carpeted. Ceiling ratings do not apply to spaces with background sound masking. Where background sound masking is used, the system should be designed by a qualified acoustical consultant.

6) Class D Spaces: Occupied spaces where speech privacy is not a significant consideration, such as internal corridors, circulation stairs and file rooms, are part of this category.

   a) The same criteria apply as for Class C1, except that noise isolation is not a requirement.

7) Class E Spaces: These are public spaces and support spaces: lobbies, atria, toilets, and locker rooms.

   a) The design ambient noise levels must not exceed class NC 40.

   b) There are no specific sound isolation requirements, but Class E spaces should be separated as far as possible from quiet areas. In large lobbies, acoustical treatment must be provided on some surfaces to mitigate reverberation, especially if the space is programmed for assembly uses.

8) Class F Spaces: These are warehouses, parking garages, and fire stairs not used for normal circulation.

   a) The design ambient noise levels must not exceed NC 50.

   b) Class F spaces should be separated as far as possible from quiet areas.

9) Class X Spaces: These are spaces where noisy operations are located, including kitchens, mechanical, electrical and communications equipment rooms, elevator machine rooms and trash compactor rooms.

a) The design ambient noise level has no fixed limit, but treatment should be considered if NC 60 is exceeded.

b) Sound isolation between Class X spaces and other spaces shall be a minimum of STC 45. Consideration must be given to sound transmission through floors and ceilings to spaces above and below. Sound isolation floors are recommended for all mechanical room floors where space below is occupied.

D. Sound Isolation From Exterior Noise Sources. The exterior construction systems recommended in these standards will screen out ordinary traffic noise. Buildings located near airports or other sources of high noise levels shall have special exterior glazing and gasket systems, designed with the assistance of a qualified acoustical consultant.

3.5 BUILDING ELEMENTS

3.5.1 Exterior

A. Configuration and Orientation. The configuration and orientation of any new structure shall be carefully analyzed to make optimum use of site potentialities and to reduce energy consumption. When selecting highly reflective exterior finishes, the designer shall establish whether surrounding structures will be adversely influenced by increased solar load and, if so, avoid the adverse impact by properly locating these surfaces. To the extent allowed by site constraints, the design shall be such that existing neighboring structures that make use of passive or active solar design shall not be compromised by the new design.

B. Roofing. Roof drains shall be located at low points. Buildings with nominally flat roofs, shall have the finished roofing system sloped a minimum of 1/4-inch per foot to the roof drains. The pattern of roof drains, high points, and slope to drain shall be indicated on the roof plan. White, reflective, cool roofing is required to reduce heat load unless there is an architectural requirement preventing it, for instance, matching an adjacent roof or campus style. If cost effective, strategies like highly reflective or vegetative roofs to minimize consumption of energy, water or materials are encouraged. See http://www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf.

C. Roof-Mounted Equipment. Since it is a potential source of leaks, roof mounted equipment shall be held to a minimum. Wherever possible, roof penetrations shall be consolidated or grouped together utilizing a common roof curb flashing platform.

Permanent access shall be provided to roof mounted equipment requiring maintenance. The access shall be from the building interior, preferably a permanent stairway or door leading onto the roof from a penthouse or a higher portion of the building. Where this is not feasible, a permanently installed ship's ladder to a roof hatch of the counterbalanced type shall be provided. The access shall be located in a portion of the building available to operating and maintenance personnel at all times. Walkways or duckboards shall be provided on the roof along routes to and around equipment requiring maintenance. Where the walkways are close to a vertical drop of 12 inches or more, they shall be provided with handrails to prevent falling.

Supports for cooling towers and other equipment shall not be constructed directly on the roof membrane. If such equipment must be located on the roof, a supplementary elevated roof platform shall be constructed to minimize membrane penetrations. The supplementary platform shall extend a minimum of three feet clear around the perimeter of the equipment and permit access to the roof surface below. Penetrations in the roof deck shall be protected against leakage. For existing buildings, the structural capacity of the existing roof structure shall be determined before equipment is redesigned.

D. Windows and Glazing. Safety glass shall be used for glazed doors and sidelights, and other areas adjacent to, or in, the line of pedestrian traffic. Partitions and exterior fenestration that are glazed to the floor line shall have protective barriers at push bar height. Low E coated insulating glass units and thermally broken framing systems are required. Products shall conform to the standards of applicable major industry associations such as the American Architectural Manufacturers Association (AAMA) and the North American Fenestration Standard/Specification (NAFS).

Air infiltration of exterior glazing systems, whether fixed or operable, shall be in accordance with ASHRAE 90.1. Exterior windows shall be provided with an internally controllable shading device. The type and location of shading systems shall be based on the building exposure and tenants' occupancy. For physical security design considerations, refer to sections 1.4 and 3.2.

E. Building Entry. Weather protection for building entry areas shall be provided by such methods as building overhangs, entry vestibules, canopies, roof projections, or recessed doorways. Designs shall attempt to minimize the accumulation of snow at building entrances through use of canopies, overhangs, and other such devices. For physical security design considerations, refer to sections 1.4 and 3.2.

3.5.2 Interior

A. Floors. For acoustical considerations, carpet or carpet tile is required in office space designed to accommodate open plan or office landscaped space. To facilitate removal when remodeling or renovation is necessary, carpeting shall be attached to a substrate with strippable adhesives, whenever it is glued. For foam backed carpeting and carpeting with a separate pad, use stretch type installation.

B. Ceilings. The minimum clear finish ceiling height, i.e., vertical distance from floor to lowest finish material or obstruction above, shall be eight feet; however, there may be other job related factors to be considered which necessitate a higher ceiling, such as addition of access floor for computer areas.

For fire safety considerations, a suspended ceiling is unacceptable as a component of a fire resistive floor/ceiling assembly. If a fire rating is required with steel joist construction, a permanent fire-resistive membrane must be fixed to the underside of the joists. Approved designs are illustrated in the Underwriter Laboratories Fire Resistance Directory. If desired, an additional finished ceiling may be suspended below.

Where it is necessary to obtain access to the space above a suspended ceiling for maintenance work, the ceiling shall be fully accessible. No panel shall exceed 16 square feet in size in order to facilitate removal by one person.

C. Doors. Except for closet doors, minimum door width shall be three feet and minimum height shall be six feet eight inches. In order to permit future lowering of suspended ceilings, tops of doors shall be a minimum of one foot below the ceiling.

Fire doors shall meet the requirements contained in National Fire Protection Association (NFPA) Standard No. 80. Doors, hardware, and frames of fire door assemblies shall bear the label of the Underwriter Laboratories, Inc., Factory Mutual, or other approved testing laboratory in accordance with ASTM E 152.

D. Finishes. Walls within general work spaces shall be painted a single neutral color with a semi-gloss or gloss finish. The number of coats shall be held to a minimum, but must completely cover the existing substrate, and the designer shall consider this factor in selecting the color.

In order to reduce lighting loads, light colors shall be used for painted and unpainted surfaces in general work spaces. Ceilings shall have a coefficient of reflectivity of not less than 75 percent, walls not less than 50 percent, and floors not less than 20 percent.

3.6 BUILDING SUPPORT SPACES

3.6.1 Service Areas

Building service areas (i.e., ancillary areas of a building that house its maintenance/ operational support functions) shall be located to best serve their function. Partitions in such locations shall be constructed of durable easily maintained materials, such as masonry or concrete.

Centrally located service closets and gear rooms shall be provided on each floor as close as possible to the elevators. Adequate, easily accessible storage facilities shall be provided for all required exterior ground maintenance equipment.

3.6.2 Mechanical/Electrical Spaces

Building design shall incorporate adequate access and space to permit the installation, maintenance, and replacement of mechanical and electrical equipment. Effective means must be included in the design to prevent the transmission of objectionable noise and vibration. Use of acoustical material in research laboratories and animal rooms may be restricted or prohibited.

3.6.3 Parking Facilities

For dimensional criteria involving maneuvering clearances and layouts for parking facilities, refer to the AIA publication "Architectural Graphic Standards."

3.7 MISCELLANEOUS ARCHITECTURAL ISSUES

3.7.1 Building Accessories

A. Flagpoles. A ground mounted flagpole, located at the left of the building entrance, shall be provided for new ARS buildings. Where ground mounted poles are not feasible, a roof mounted pole is permissible; or, if roof mounting is not suitable, an outrigger pole may be used. Only one flagpole need be provided for a complex of buildings on a common site. Flagpoles shall be of standard economical design and manufacture.

B. Identification Signs, Building Directories, and Bulletin Boards. When required by the project, the identification signs, building directories, and bulletin boards shall be designed in compliance with the requirements specified in P&P 243.2 -

REE Signage Policy.

C. Lightning Protection. All metal flagpoles and metal stacks either attached to buildings or free standing shall be grounded. See section 6.12.4.

3.7.2 Specifying Uncommon Products

A. General. In historical preservation or restoration work and special laboratory or laboratory support work, it may be necessary to specify materials or products which are not commonly used and may be hard to find. In such cases it is permissible to specify the source of the uncommon product by stating the supplier's name, address, and trade name of the product subject to the following conditions:

1) When more than one source of the uncommon product is found, each source shall be named.

2) The project specification shall contain the following statement: "*The use of a trade name and supplier's name and address in the specification is to indicate a possible source of the product. The same type of product from other sources shall not be excluded, provided they possess like functional performance, physical characteristics, color, and texture. If the product is from a foreign supplier, it shall be subject to the Buy American Act.*"

Appendix 3A: Architectural Design Submission Requirements

3A-1. 15 Percent Architectural Design

This submittal stage is required on the more complex projects, and/or where architectural design elements are required to obtain coordinated interior design development, or development of exterior design considerations.

A. Drawings

Three or more distinctly different architectural design schemes and sufficient narrative to allow comparison and selection of a design direction. Each design scheme shall include:

1) schematic floor plans indicating spatial relationships and functional arrangements, and elevations

2) schematic site plans for each alternate indicating building location and orientation, approximate grades, and landscaping

B. Narrative

1) Description of each architectural design scheme, explaining: organizational concept, expansion potential, building efficiency, energy and water efficiency and sustainable design considerations, security considerations, advantages and disadvantages, and historic preservation considerations, if applicable.

2) List of applicable code and code statement. Building classification, occupancy groups, fire-resistance requirements, and general egress requirements that relate to the site and occupancy use.

3) Construction cost of alternative schemes. Verify that each design scheme presented can be constructed within the project budget.

3A-2 Conceptual Architectural Design

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Occupant load and egress calculations.

3) Building area calculations and calculated occupant loads for every space and room in the building.

4) Building efficiency ratio calculations.

5) Validation of laboratory and animal space program requirements.

6) Acoustical requirements.

7) Toilet fixture count.

8) Fire resistance rating of building structural elements.

9) Review of building compliance with life safety requirements and building security requirements.

10) Interior finishes requirements as they pertain to life safety.

11) Responses to the 15 percent Review Comments

12) Completed A-E Design Checklist.

B. Drawings and Specifications

1) Floor plans, showing as a minimum: entrances, lobbies, corridors, stairways, elevators, work areas, special spaces, and service spaces (with the principal spaces labeled). Also, floor plans shall show locations of firewalls, smoke partitions, and occupancy type for every space and room in the building shall be identified. Dimensions for critical clearances, such as vehicle access, should be indicated.

2) Building sections (as necessary), showing: floor-to-floor heights and other critical dimensions, labeling of most important spaces, and labeling of floor and roof elevations.

3) Perspective sketches, renderings and/or presentation model, if included in the project scope.

4) Diagrams illustrating the ability to access, service, and replace mechanical/electrical equipment showing the pathway with necessary clearance.

5) Location of accessible pathways and services for the physically disabled.

6) List of specification sections to be used.

7) Narrative description of architectural design intent, laboratory and animal space program, recommendation for exterior and interior materials to be used, and issues to be addressed during the 35 percent design phase.

3A-3 35 Percent Architectural Design

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Occupant load and egress calculations.

3) Building area calculations and calculated occupant loads for every space and room in the building.

4) Building efficiency ratio calculations.

5) Validation of laboratory and animal space program requirements.

6) Acoustical requirements.

7) Toilet fixture count.

8) Fire resistance rating of building structural elements.

9) Review of building compliance with life safety requirements and building security requirements.

10) Interior finishes requirements as they pertain to life safety.

11) Responses to the 15 percent Review Comments

12) Completed A-E Design Checklist

B. Drawings and Specifications

1) Floor plans, showing as a minimum: entrances, lobbies, corridors, stairways, elevators, work areas, special spaces and service spaces (with the principal spaces labeled). Also, floor plans shall show locations of firewalls, smoke partitions, and occupancy type for every space and room in building shall be identified. Dimensions for critical clearances, such as vehicle access, should be indicated.

2) Building sections (as necessary), showing: floor-to-floor heights and other critical dimensions, labeling of most important spaces, and labeling of floor and roof elevations.

3) Perspective sketches, renderings, and/or presentation model, if included in the project scope.

4) Diagrams illustrating the ability to access, service, and replace mechanical/electrical equipment showing the pathway with necessary clearance.

5) Location of accessible pathways and services for the physically disabled.

6) List of specification sections to be used.

7) Narrative description of architectural design intent, laboratory and animal space program, recommendation for exterior and interior materials to be used, and issues that were not resolved during conceptual design phase.

3A-4 50 Percent Architectural Design

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Responses to the 35 percent Review Comments.

3) Completed A-E Design Checklist.

B. Drawings and Specifications.

1) Building floor plans, showing: spaces individually delineated and labeled,

enlarged layouts of special spaces, and dimensions.

2) Building roof plan, showing: drainage design, including minimum roof slopes, dimensions, and a membrane and insulation configuration of the roofing system.

3) Elevations, showing: entrances, window arrangements, doors, exterior materials with major vertical and horizontal joints, roof levels, raised flooring and suspended ceiling space, and dimensions.

4) One longitudinal and one transverse section, showing: floor-to-floor dimensions, stairs and elevators, typical ceiling heights, and general roof construction.

5) Exterior wall sections, showing: materials of exterior wall construction, including flashing, connections, method of anchoring, insulation, vapor retarders and glazing treatments, and vertical arrangement of interior space including accommodation of mechanical and electrical services in the floor and ceiling.

6) Marked up specifications.

7) Room finish schedules.

8) Acoustical calculations.

9) Approval Draft of colored perspective rendering.

3A-5 95 Percent Architectural Design Submittal

A. Design Analysis.

1) Any revisions from the 50 percent submittal.

2) Responses to the 50 percent Review Comments.

3) Completed an A-E Design Checklist.

B. Drawings and Specifications

1) Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

2) Final version of colored perspective rendering.

3A-6 100 Percent Architectural Design Submittal

A. Design Analysis

1) Complete Design Analysis incorporating the final calculations, narrative, equipment selections, final completed A-E Design Checklist review comments etc.

2) Responses to the 95 percent Review Comments.

B. Drawings and Specifications

1) Complete drawing and specification package suitable to “Issue for Bidding and Construction.”

2) Listing of applicable codes.

Appendix 3B: Architectural Design Coordination Checklist

3B-1. General

This checklist enumerates some of the interfaces between architectural and engineering disciplines that require close coordination.

A. Interference with structural framing members coordinated.

B. Locations and details of below-grade and other waterproofing shown, and coordinated with structural drawings.

C. Anchorage of exterior wall elements shown.

D. Expansion and/or seismic joints shown, properly sized, detailed, and are continuous throughout the building.

E. Adequate clearances to install, service, repair and replace mechanical and electrical equipment. (Verify all space requirements are incorporated into the floor plans.)

F. Rooftop mechanical equipment shown.

G. Adequate clearances under rooftop mechanical and electrical equipment to facilitate maintenance, repair, and replacement of the roofing system.

H. Location of roof drains and floor drains coordinated with mechanical drawings.

I. Air diffusers and registers coordinated with mechanical drawings.

J. Louver sizes and locations coordinated with mechanical drawings.

K. Light fixture types and locations coordinated with mechanical and electrical drawings.

L. Wall and roof sections coordinated with heat loss calculations.

M. Adequate envelope design details to ensure thermal/air/moisture control.

N. For a pressurized plenum raised flooring, assure an effective barrier to prevent air passage to exterior walls.

O. Acoustical wall treatments shown in mechanical rooms (if applicable).

P. Location of access panels in plaster ceilings and soffits coordinated with mechanical drawings.

Q. Plumbing fixture mounting heights coordinated with mechanical drawings.

R. Coordination of architectural elements with exposed structural members.

S. Location of air supply and exhaust duct systems and louvers coordinated horizontally and vertically with other utility systems (lighting, sprinkler, etc.), building structure, and architectural finishes.

T. Security light fixtures required and locations coordinated with electrical drawings.

U. Verify that property line dimensions on survey or civil site plans match architectural drawings.

V. Verify that building sections match elevations and plans. Check roof lines, windows, and door locations.

W. Verify that large scale partial floor plans match small scale floor plans. Do not repeat dimensions, door and room numbers, and other unnecessary or redundant information.

X. Verify that reflected ceiling plans match architectural floor plans to ensure no variance with wall locations.

Y. Verify that cabinets will fit in available space and that electrical outlets on cabinet walls are the right height.

Z. Verify that the location of fire rated walls matches the location of fire and/or smoke dampers on mechanical plans. Verify that the wall ratings are continuous.

AA. Coordinate size of openings for windows and doors on plans, elevations, and schedules so that openings on the architectural and structural floor plans match. Verify that structural X- bracing does not conflict with window or door openings. Verify that window glass types on drawings and schedules match specifications. Provide a shim space in the construction details for door and window frames to allow for irregularities in rough construction so that windows and doors will install as intended.

AB. Verify that door schedule information matches plan, and elevation information including sizes, types, labels, etc. Look for omissions and inconsistencies.

AC. Verify that room finish schedule information matches plan and elevation information including room numbers, names of rooms, finishes, and ceiling heights. Look for omissions and inconsistencies. Look at the schedule for obvious omissions by checking that all boxes are filled in and for inconsistencies with plans.

AD. Verify that the mechanical drawings indicate fire and/or smoke dampers at fire rated walls. The fire rated walls will usually appear on the architectural floor plans and/or reflected ceiling plans. Verify that the wall ratings are continuous and have no gaps. Overlay the architectural floor plans with the mechanical ductwork drawings to determine conflicts and omissions.

4. STRUCTURAL AND GEOTECHNICAL ENGINEERING

4.1 GENERAL

4.1.1 Scope

This chapter provides general objectives and criteria pertinent to design of structural elements for ARS buildings.

4.1.2 Codes and Standards

A. General. The design shall comply with the requirements of the site applicable codes and standards that apply to structural system design. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the project's design and construction. See Chapter 1: *Basic Requirements* for complete discussion of codes and other special requirements.

B. Structural Design Standards. The planning and design shall conform with the latest edition of the following publications and codes:

1) International Building Code (IBC)

2) American Concrete Institute (ACI)

3) American Institute of Steel Construction (AISC)

4) Building Code Requirement for Masonry Structures

5) American Society of Civil Engineers (ASCE), Minimum Design Loads for Buildings and other Structures

6) National Design Specification for Wood Construction and Supplement

C. Code Review, Analysis, and Waiver Process. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that tasks accomplished during design meet code requirements. All deviations from code/ARS requirements and any equivalency concepts proposed for use must be identified by the A-E and submitted to the government for approval no later than the 35 percent design stage. See Chapter One for requirements.

4.1.3 Structural Design Submissions and Coordination

A. General. The A-E shall submit structural design concepts, drawings, sketches, calculations, specifications, etc. at various stages throughout the design process as outlined in the A-E contract. Refer to section 1.9, *Design Documentation* and Appendix 4A, *Structural Design Submission Requirements*.

B. Coordination Checklist. To insure inter-discipline and intra - discipline coordination, a review checklist is provided in Appendix 4B, *Structural Design Coordination Checklist*. The A-E shall make sure that all of these items, and others that pertain to good project coordination, are reviewed and addressed before submission of the documents to ARS.

C. Geotechnical Investigation. If a geotechnical investigation is part of the scope of work for the project, see Appendix 4C, *Geotechnical Investigation and Engineering Report* for information requirement.

4.2 STRUCTURAL SECURITY DESIGN

4.2.1 General

A. Appropriate structural engineering security design criteria and standards for a project shall be determined based on project-specific risk assessment done in accordance with the methodology outlined in the Physical Security Federal Facilities Standard, Security Level Determinations for Federal Facilities.

B. The structural criteria shall address bombing, forced entry, and small arms tactics. The intent shall be to reduce the potential for widespread catastrophic structural damage and the resulting injury to people.

C. For new construction, the criteria shall require protection against progressive collapse as well as resistance to blast loads. For existing construction, however, progressive collapse measures are called for only if the structure is undergoing a structural renovation, such as a seismic upgrade. The same blast features that apply to new buildings apply to existing buildings if technically and economically feasible.

4.2.2 General Requirements

A. Designer Qualifications. A blast engineer must be included as a member of the design team, when required by ISC Security Design Criteria guidelines. He or she should have formal training in structural dynamics and demonstrated experience with accepted design practices for blast resistant design and with referenced technical manuals.

B. Design Narratives. A design narrative and copies of design calculations shall be submitted at each phase identifying the building specific implementation of the criteria. Security requirements shall be integrated into the overall building design starting with the planning phase.

C. Compliance. Full compliance with the risk assessment and this section is expected. Specific requirements should be in accordance with the findings of the facility Security Risk Assessment (SRA).

D. Guiding Documents: The security risk assessment and the physical security design shall be completed in accordance with the procedures and requirements contained in the latest editions of the following guiding documents:

1. Interagency Security Committee, Physical Security Criteria for Federal Facilities (FOUO).

2. Interagency Security Committee Standard, Facility Security Level Determinations for Federal Facilities (FOUO).

3. Homeland Security Presidential Directive 12: Policy for a Common Identification Standard for Federal Employees and Contractors.

4. U.S. General Services Administration Public Building Services Security Guidelines and Design, Facilities Standards for Public Buildings Service.

5. USDA Physical Security Interim Policy, PGM-04-004, August, 2004.

6. USDA Common Identification Standard for Employees and Contractors, Departmental Manual DM 4620-002, 2009.

7. USDA Integrated Physical Security Standards and Procedure Manual (IPSSPM), Draft 2008.

8. USDA Security Policies and Procedures for Laboratories and Technical Facilities (Excluding Biosafety Level-3 Facilities), Departmental Manual DM-9610-2, 2003.

9. USDA Security Policies and Procedures for Biosafety Level -3 Facilities, Departmental Manual DM-9610-1, 2002

10. USDA-ARS Policy Guidance, PGM-02-005, Physical Security in IT Restricted Space.

4.3 FOUNDATIONS

4.3.1 Procedures and Criteria for the Analysis and Design of Foundations for Buildings

A. The A-E, with the geotechnical consultant, shall prepare all necessary documents to contract for subsurface soil exploration. The Project Requirements Document (PRD) and related documents must be submitted to the Contracting Officer (CO) for approval.

B. The A-E shall submit recommendations for foundation systems based on data contained in the subsurface investigation report. An economic comparison of the alternate foundation systems shall be made and submitted with each tentative submission.

C. After review and approval of the design concept by the EPM, the A-E shall prepare the foundation design.

D. Consultant geotechnical engineering services shall be provided for projects and related work that require subsurface engineering analysis.

4.3.2 Subsurface Investigation

A. General. The A-E, along with the geotechnical consultant, shall develop the subsurface investigation program. The subsurface investigation shall be of sufficient scope to provide the A-E with adequate information to design the foundation system and assist with layout of the proposed structures as may be required. Where borings are required, the A-E shall prepare a boring location plan and specifications in conformity with requirements of this section.

Upon written authorization from the CO, the A-E shall contract for the subsurface investigation work. The contract shall be awarded after authority for right of entry onto the property has been issued, and after approval by the CO of the soils investigation contract.

B. Geotechnical Report. The report on the subsurface investigation and geotechnical consultant's recommendations for type of foundation, allowable soil bearing values based on bearing capacity and settlement analysis, and protection against surface and subsurface water, shall be submitted to the CO for approval. Pros and cons evaluation of systems and subsystems divided into a technical part and a cost comparison chart shall be provided. Refer to Appendix 4C, *Geotechnical Investigation and Engineering Report*.

4.3.3 Foundation Design

A. Basis for Foundation Design. Foundation design shall proceed on the basis of the approved geotechnical report. Foundations must satisfy the following requirements:

1) Ultimate bearing capacity of soils must be sufficiently larger than design loads to ensure foundation safety.

2) Total differential settlements must be sufficiently smaller than settlement tolerance of the structure to ensure that the structure will function properly.

3) Effects of the structure and its construction operation on adjoining property, buildings and facilities, must be examined and evaluated, and protective measures must be taken.

B. Foundation Depths. At a minimum, bottom of the footings shall be located one foot below the frost line. Footings shall not be located in zones of high volume change due to moisture fluctuations. Footings shall not bear on soft, expansive or un-compacted soils. The water table and its fluctuation record should be obtained before establishing elevation of the foundation.

Individual footings on pile caps shall be braced to resist lateral forces in seismic areas in accordance with requirements of the governing State/local building code or Federal Standards.

C. Protection and Support of Adjoining Property. Building codes of cities differ in the requirements for the protection of adjoining property. Local building codes shall be checked in each case to determine where temporary or permanent protection is required. When construction of such protection requires access to adjoining property, the CO shall be notified so that the CO, through the appropriate real property office, may obtain the necessary permission.

The contractor shall design and provide sheet piling, underpinning, shoring, and bracing to protect banks and sides of excavation, buildings, structures, facilities, and utilities adjacent thereto against damage including that from surface drainage. The project specifications shall be developed to require the contractor to conduct a survey of the condition of adjoining properties, including photographs and records of prior settlement or cracking of walls, partitions, or floors that may become the subject of possible damage claims. Before the start of construction, a complete survey report shall be submitted to the CO or designated representative. The A-E and his geotechnical consultant shall review design calculations and construction drawings to ensure that the contractor's design and construction procedures are safe and satisfy design criteria and geotechnical recommendations.

Permission shall be obtained from local authorities having jurisdiction before proceeding to project footings beyond the lot line onto public property.

4.3.4 Retaining Walls

To make the structure safe against failure by overturning and excessive settlement, pressure beneath the base must not exceed the allowable soil pressure, and the structure as a whole must have an adequate factor of safety with respect to sliding along its base or along some weak stratum below its base. The entire structure, as well as each of its parts, must possess adequate strength. Corresponding pressures and forces provide the basis for checking the ultimate structural strength at various critical sections.

Exposed faces of retaining walls shall be battered half an inch per foot of height to avoid the appearance of tilting. The bottom of the base of retaining walls on soil shall be below the frost line, but not less than two feet below the finished grade at the exposed face of the wall. A four inch diameter weep hole shall be provided for drainage, placed six inches above the lower grade at the exposed face of the wall, and spaced not more than fifteen feet on centers. Joints in retaining walls shall be provided in accordance with the requirements for reinforced concrete or masonry units laid with mortar.

4.4 STRUCTURAL SYSTEMS

4.4.1 Stability

Structures shall be designed with a lateral resistant system to meet stability requirements that conform to recognized engineering principles. Design stability shall provide resistance against sliding, uplift forces, and overturning moments caused by wind, gravity, and seismic forces. Choice of resistant systems shall be made by comparing rigidity of horizontal elements (floors and roof) with that of vertical elements (frame and walls).

4.4.2 Overall Considerations

The optimum structural system for a given application is one that will satisfy functional and architectural requirements of the finished structure at minimum cost. Consideration shall be given to future uses of the structure, possibilities of alterations, maintenance costs, and ease of demolition of temporary structures or dismantling of portable structures. Preferred systems utilize material efficiently, provide maximum usable space, minimize use of special equipment, and can be constructed by following conventional procedures.

4.4.3 Comparative Cost Analysis

A comparative cost analysis of the various structural systems shall be performed and submitted to the EPM for approval.

4.5 DESIGN REQUIREMENTS

4.5.1 Design Loads

4.5.1.1 Live Loads. Floor design live loads shall comply with the IBC occupancy/use minimum concentrated live loads required. Columns supporting a building roof level shall not be subjected to live-load reduction.

4.5.1.2 Dead Loads. The building shall be designed to support the actual weights of all materials. These include structural materials, finishes, ceilings, partitions, piping, ductwork, and superimposed equipment weights.

4.5.1.3 Wind Loads. The building shall be designed to comply with the IBC for the area geographic basic wind and exposure category.

4.5.1.4 Seismic Loads. Seismic loads shall be determined using the provisions of the IBC for the seismic area in which the building is located.

4.5.2 Vibration

Supports for high-speed machinery having heavy vibration tendencies, such as turbo generators, turbine driven or motor driven pumps and fans, and motor generators shall be designed to reduce vibration to a minimum.

Design beams or girders supporting machines so that maximum deflection will be within accepted limits (impact included). Take the span as the distance center-to-center of columns with the ends considered as supported without restraint. The structure shall be designed so that a horizontal transverse force, equal to one-half of the weight of the machine, applied at the level of the shaft, will not produce a horizontal deflection greater than 1/50 of an inch at the base of the machine.

Consider use of vibration and shock isolators to reduce magnitude of the force transmitted to supports for the machinery. Consider use of vibration absorbers where it is required to eliminate vibration of supporting structure. In seismic areas, all equipment shall be mounted on vibration isolators, which shall be provided with seismic restraints capable of resisting a horizontal force of 100 percent of the weight of the equipment (50 percent for equipment secured and anchored to the building).

4.5.3 Foundation Considerations

Foundations for vibrating machinery require careful consideration. Minimum weight of the foundation shall be 1.5 times the weight of vibrating machinery. In determining required foundation weight, consider the proportion of the weight of rotating or reciprocating parts of the machine to the total machine weight and restrictions on lateral movement of the foundation.

Foundations for heavy machinery shall be completely isolated from foundations and floors of buildings. The gap between machine foundation and other construction shall be at least one inch. This gap shall be maintained, clear or filled, with a soft caulking material.

4.6 ARCHITECTURAL-STRUCTURAL INTERACTION

4.6.1 Drift

Lateral deflection of a building under wind or seismic loading shall be such so as to preclude creating discomfort for occupants or damage to the superstructure. Specifically, when lateral stability is afforded by moment resisting framing, deflections of frames must be allowed to occur by providing tangible connections between masonry walls and concrete columns, walls, or beams. This form of construction shall also be considered where tall flexible shear walls are utilized in multistory buildings to obtain lateral stability. The A-E shall develop supporting calculations to verify acceptable building response under lateral loading, and shall follow the process of designing a high-rise building as outlined below.

A. Establish criteria for minimum lateral stiffness, supported by an established authority.

B. Find the geometry that results in the least material to safely sustain stresses.

C. Choose a strength level for the material to safely sustain stresses.

4.6.2 Anchoring Exterior Walls

Anchoring or bonding of exterior wall elements, such as facing stones or brick veneer, cornices, coping, precast panels, and ornamental features, shall be designed to ensure adequate support for such elements. Anchoring or bonding system shall be jointly developed by the architect and the structural engineer.

Provision shall be made for the following. The system shall take into account weight of the element itself plus loading due to wind, earthquake, or blast for which the structure was designed, construction tolerances, and loadings induced by erection process. The system shall be designed to permit anticipated movement of the element due to thermal expansion, moisture expansion, and deflection or creep of supports.

4.6.3 Nonstructural Partitions

Nonstructural partitions shall be designed and constructed to remain stable and to function compatibly with the building. Walls and partitions for interior space compartmentalization shall not be used inadvertently as structural components because of insufficient allowances for assumed or actual deformation of the building structure.

4.6.4 Curtain Walls

Curtain walls and exterior nonstructural enclosures shall be designed and constructed with suitable support and anchoring systems to function compatibly with the rest of the building. The connections to anchor the curtain wall must be designed to allow differential movement while resisting the applied loads. The curtain wall shall be designed for accessibility for maintenance.

4.6.5 Floor and Ceiling Details

Attention shall be given to type of floor covering and finishes, and to type and location of ceilings to establish correct measurements and location of structural system. Sufficient information shall be provided in contract documents by the structural engineer to convey construction requirements.

4.6.6 Cladding and Insulation

Type, location, sequence of assembly, and thickness of cladding and insulation to be used separately or together shall be coordinated with design and construction requirements. Adequate support and anchoring shall be designed for cladding and insulation.

4.6.7 Stairwells

Design and construction of stairwells shall be consistent with maintaining structural integrity and stability of stairwells and building frames. Requirements for enclosing stairwells shall be addressed in design phases.

4.6.8 Glass and Glazing Details

The structural engineer shall provide satisfactory design systems incorporating glass and glazing details to be used in the building. Their adequacy to withstand actual and assumed forces shall be considered by the structural engineer. Coordinate structural requirements with the architect.

4.6.9 Waterproofing

Attention shall be given to requirements for the type, location, and extent of waterproofing which shall be consistent with the requirements of the building structure.

4.7 REPAIR AND ALTERATION OF EXISTING BUILDINGS AND STRUCTURES

4.7.1 Design Requirements

The A-E shall be responsible for gathering information necessary to execute the professional services contract. The project may require the following functions to be performed.

A. Existing Drawings. Construction or as-built drawings shall be reviewed and data shown thereon shall be verified by field observations and measurements, before the information is used to develop a new design.

B. Subsoil Investigation. The A-E shall appraise existing subsoil information, determine the extent of additional subsurface investigation required, and submit proposed foundation design concept based on review of new or existing subsurface information.

C. Exploratory Field Work. In the absence of original contract documents, or when information is required to define in-place construction, the structural engineer shall determine the nature, location, and extent of exploratory field work.

    1) Chemical analysis may be used as a means of establishing procedures for welding to older steel framing.

2) The Magneto inductive method (reinforcing bar detector) may be used to determine size and location of reinforcing in the concrete members.

D. Structural Calculations. A decision to use the existing structure for purposes not originally intended shall be supported by structural calculations for affected framing elements. Calculations may reflect current design approaches such as live load reduction factors and unit loads for various occupancies. Careful judgment, supported by necessary testing, shall be exercised as to whether the usefulness of deteriorating members can be effectively extended.

E. Hazardous Materials/Waste. The A-E shall be responsible for identifying hazardous materials which may affect the project activities. The A-E shall use certified inspectors and planners for any hazardous materials investigation. Laboratory analysis of sample materials may be required. Examples of hazardous materials are asbestos, lead paint, and PCBs.

1) The A-E shall be responsible for securing any permits/approvals which may be required to perform the work.

2) The A-E shall determine if waste generated is hazardous waste, and shall properly manage and dispose of any waste generated by the project activities.

4.7.2 Fire Safety

For extensions to buildings, the fire-resistant rating of the existing structure shall be upgraded to conform to current fire safety criteria. If this is not feasible, fire wall separation may be required to isolate new from existing areas. In no case shall a major alteration reduce the fire-resistant rating of the building below that afforded by the original structure. The A-E shall perform a complete code analysis of the extension related to the existing structure.

4.7.3 Foundations

The ability of new foundations to support new construction adjacent to old construction must be carefully considered. Where stress applied to the soil may cause consolidation of the soil, the A-E shall establish initial floor elevations to accommodate anticipated vertical movement so that final adjacent surfaces in connecting halls and passageways are at or near the same elevation. The adverse effect of construction operations on the existing structure, such as pile driving, shall be recognized and guarded against. An estimate of settlement anticipated, supported by calculations, shall be included with the submittal by the A-E. Use of reduced allowable bearing pressures for spread foundations, or use of foundations such as caissons or piles, for new construction may reduce differential settlement between old and new structures. Preloading of the site may also be considered, provided it does not adversely affect the old construction. To allow for possible differential settlement between new and old construction, use of expansion joints may also be investigated.

4.7.4 Connection to Existing Framing

Contract documents shall clearly delineate aspects of construction that require special attention.

Following is a partial list of items that shall be covered. Existing steel framing shall be adequately shored and braced if extensive welding is to be made thereto. When holes or expansion shields are to be installed in existing concrete framing elements, extreme care shall be exercised to avoid cutting or damaging main reinforcement. The Magneto inductive method (reinforcing bar detector) may be a useful tool to determine the location of the reinforcement. If a special sequence is essential for the successful completion of construction, it shall be clearly defined in the drawings and specifications.

4.7.5 Contract Documents

Contract documents shall be developed in a manner that will clearly indicate the work to be performed. In addition, a system shall be devised that will clearly differentiate between new and existing construction and will define the limits of the contract. Live loads for adjacent existing areas shall be noted on the structural plans to aid the construction contractor in determining construction live loads in staging and demolition areas.

4.7.6 Wind and Seismic Designs

A. General. Often, construction details of older buildings are not consistent with current criteria for wind or seismic loading. Therefore, careful judgment (supported by structural calculations) shall be used to determine whether the new and existing unit should be separated, or tied together to make them respond in unison. The latter approach is reserved for low, light structures where connections can be devised that will satisfactorily transmit internal stresses.

B. General Design Considerations for Structural Upgrading Seismic Performance

1) Executive Order 12941, Seismic Safety of Existing Federally Owned or Leased Buildings, adopted "*ICSSC RP4, Standards of Seismic Safety for Existing Federally Owned or Leased Buildings*" published by the

Interagency Committee on Seismic Safety in Construction (ICSSC) as minimum standards for all future seismic safety evaluation and rehabilitation projects for federally owned or leased buildings.

2) The performance objective of a seismic upgrade is life safety, defined as the safeguarding against partial or total building collapse, obstruction of entrance or egress routes, and the prevention of falling hazards in a design basis earthquake. Seismic upgrades will be considered based on the buildings' structural vulnerability and economic feasibility of implementation.

3) The following Guidelines shall be incorporated into the structural design for all projects:

A. New Building Construction:

1) *NEHRP* (National Earthquake Hazards Reduction Program) *Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, FEMA 4504502* American Society of Civil Engineers: *Minimum Design Loads for Buildings and Other Structures, ASCE/SEI 7-05.*

C. Existing Building/Renovations:

1) *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings* (ICSSC RP 4)(NISTIR 6762) prepared by the Interagency Committee on Seismic Safety in Construction..

2) American Society of Civil Engineers: Seismic Rehabilitation of Buildings, ASCE 41.

Appendix 4A: Structural Design Submissions

4A-1. 15 Percent Design Submittal

A. Drawings.

Plans, showing framing plans of the proposed structural system showing column locations; bay sizes; and location of expansion or seismic joints.

B. Narrative.

1) Identification of unusual local code requirements, related to the site and occupancy use.

2) Code compliance statement including: names of model building codes followed; building classification; identification of seismic zones;; wind speed, etc.; and identification of special requirements, such as high rise..

3) For new buildings located in moderate and high risk seismic areas only:

a.) Statement certifying that the structural engineer has reviewed the building configuration for seismic adequacy. This statement must be signed by the structural engineer and the architect.

4A-2. 35 Percent Design & Conceptual Design Submittals

A. Design Analysis

1) Identify all code requirements and provide a complete analysis as it pertains to this project including but not limited to:

a.) Required fire-resistance rating of structural elements.

b.) Summary of special requirements resulting from applicable local codes.

2) Comparative cost analysis of at least three potential framing systems.

3) Description of recommended structural concept, including:

a.) Choice of framing system, including lateral load-resisting elements, and proposed foundation design.

b.) Verification of adequacy of all assumed dead and live loads.

4) Geotechnical Engineering Report, including final boring logs (if part of scope of work). See Appendix 4C, *Geotechnical Investigation and Engineering Report.*

5) Responses to the 15 percent Review Comments

B. Drawings and Specifications

1) Framing plans and key details.

2) List of specifications sections to be used.

4A-3. 50 Percent Design Submittal

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Narrative description of structural systems.

3) Gravity load and lateral load calculations, with tabulated results showing framing schedules.

4) Foundation calculations.

5) Calculations showing that the system is not vulnerable to progressive collapse.

6) Vibration calculations.

7) Blast calculations.

8) Responses to the 35 percent Review Comments.

B. Drawings and Specifications.

1) Structural plans and key details.

2) Marked-up specifications.

3) Preliminary schedules for foundations, columns, walls, beams, slabs, and decks, as applicable.

4A-4. 95 Percent Design Submittal

A. Design Analysis.

1) Any revisions from the 50 percent submittal.

2) Responses to the 50 percent Review Comments.

B. Drawings and Specifications

1) Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

4A-5. 100 Percent Design Submittal

A. Design Analysis

1) Complete Design Analysis incorporating the final calculations, narrative, equipment selections, review comments etc.

2) Responses to the 95 percent Review Comments.

B. Drawings and Specifications

1) Complete drawing and specification package suitable to "Issue for Construction." Listing of applicable codes.

Appendix 4B: Structural Design Coordination Checklist

4B-1. General

This checklist enumerates some of the interfaces between structural engineering, architectural and other engineering disciplines that require close coordination.

A. Floor elevations shown on drawings.

B. Camber requirements shown on drawings.

C. Beam and girder connections detailed.

D. Clearances for bolts and fasteners shown (steel and wood construction).

E. Fire resistance of structural members indicated.

F. Beam reactions shown for moment connections.

G. Equipment, piping and ductwork supports detailed (may be shown on structural, mechanical or electrical drawings, as applicable).

H. Hoists shown in major mechanical rooms (if required).

I. Interference with piping and ductwork coordinated.

J. Interference with electrical ducts and conduit coordinated.

K. Anchorage of architectural, mechanical or electrical systems and components.

L. Roof drains coordinated with architectural and mechanical drawings.

M. Sub drainage and foundations coordinated with mechanical drawings/piping.

N. Waterproofing of foundation walls, retaining walls and other structural elements coordinated with architectural drawings.

Appendix 4C: Geotechnical Investigation and Engineering Report

4C-1. General

The requirements for geotechnical work for the building designs are defined here – in accordance with GSA "Facility Standards for the Public Buildings Service" (PBS-P100). They apply whether ARS contracts for geotechnical work separately or includes the geotechnical investigation in the scope of the A-E services.

4C-2. Purpose

The purpose of the geotechnical investigation during building design is to determine the character and physical properties of soils or rock strengths, stability, settlement characteristics, etc. The type of structure to be built and anticipated geologic and field conditions has a significant bearing on the type of investigation to be conducted. The investigation must therefore be planned with a knowledge of the intended project size and anticipated column loads, land utilization and a broad knowledge of the geological history of the area.

The guidelines given here are not to be considered as rigid. Planning of the exploration, sampling and testing programs and close supervision must be vested in a competent geotechnical engineer and/or engineering geologist with experience in this type of work and licensed to practice engineering in the jurisdiction where the project is located.

4C-3. Analysis of Existing Conditions

The report shall address the following:

A. Description of terrain.

B. Brief geological history.

C. Brief seismic history.

D. Surface drainage conditions.

E. Groundwater conditions and associated design or construction problems.

F. Description of exploration and sampling methods and outlines of testing methods.

G. Narrative of soil identification and classification, by stratum.

H. Narrative of difficulties and/or obstructions encountered during previous explorations of existing construction on or adjacent to the site.

I. Description of laboratory test borings and results.

J. Plot plans, drawn to scale, showing test borings or pits.

K. Radon tests in areas of building location.

L. Soils resistivity tests, identifying resistivity of soil for corrosion protection of underground metals and electrical grounding design.

M. Boring logs, which identify sample number and sampling method. Other pertinent data deemed necessary by the geotechnical engineer for design recommendations, such as:

   1) Unconfined compressive strength.

   2) Standard penetration test values.

   3) Subgrade modulus.

   4) Location of a water table.

   5) Water tests for condition of groundwater.

   6) Location and classification of rock.

   7) Location of obstructions.

   8) Atterberg tests.

   9) Compaction tests.

   10) Consolidation tests.

   11) Triaxial compression tests.

12) Chemical tests (pH) of the soil.

13) Contamination.

4C-4. Engineering Recommendations

Engineering recommendations based on borings and laboratory testing shall be provided for the following:

A. Recommendations for foundation design, with discussion of alternate solutions, if applicable, including:

1) Allowable soil bearing values.

2) Feasible deep foundation types and allowable capacities, where applicable, including allowable tension (pull out) and lateral subgrade modulus.

3) Feasibility of a slab on grade versus structurally supported ground floor construction including recommended bearing capacities and recommended subgrade modulus.

4) Discussion of evidence of expansive surface materials and recommended solutions.

5) Lateral earth design pressures on retaining walls or basement walls, including dynamic pressures.

6) Design frost depth, if applicable.

7) Removal or treatment of objectionable material.

8) Discussion of potential for consolidation and/or differential settlements of substrata encountered with recommendations for total settlement and maximum angular distortion.

9) Use and treatment of in-situ materials for controlled fills.

10) Recommendations for future sampling and testing.

11) Recommendations for pavement designs, including base and sub-base thickness and sub-drains.

12) Recommendations for foundation and sub-drainage, including appropriate details.

13) Discussion of soil resistivity values.

14) Discussion of radon values and recommendation for mitigating measures, if required.

5. MECHANICAL

5.1 GENERAL

5.1.1 Objective

The Heating, Ventilation, and Air Conditioning (HVAC), Plumbing, and Fire Protection systems shall be selected for long-term durability, energy efficiency, flexibility, accessibility, ease of operation and maintenance, and efficient life-cycle ownership and operating costs.

5.1.2 Codes and Standards

A. The design shall comply with the requirements of the site applicable codes and standards, including the guidelines referenced therein, that apply to mechanical and plumbing system design. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the project's design and construction.

See Chapter 1, for complete discussion of codes and other special requirements.

See Chapter 7, for additional requirements for safety and health.

See Chapter 9, for additional requirements for biohazard containment design.

See Chapter 10, for additional requirements for animal facilities.

B. <u>Mechanical Design Standards.</u> The design shall conform to the following publications and codes. The term "Recommended" as used in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards shall be considered "Required".

1) National Fire Protection Association: National Fire Codes

2) American National Standards Association: ANSI Z 9.5 *American National Standard for Laboratory Ventilation*

3) American National Standards Association: ANSI Z358.1 *American National Standard for Emergency Eyewash and Shower Equipment*

4) ASHRAE: Handbook of Fundamentals

5) ASHRAE: Handbook of HVAC Applications

6) ASHRAE: Handbook of Refrigeration

7) ASHRAE: Handbook of HVAC Systems and Equipment

8) ASHRAE: Standard 15: *Safety Standard for Mechanical Refrigeration*

9) ASHRAE: Standard 62.1: *Ventilation for Acceptable Indoor Air Quality*

10) ASHRAE: Standard 90.1: *Energy Standard for Buildings Except Low-Rise Residential Buildings*

11) ASHRAE: Standard 100: *Energy Conservation in Existing Buildings*

12) ASHRAE: Guideline 12: *Minimizing the Risk of Legionellosis Associated with Building Water Systems*

13) National Standard Plumbing Code (NSPC)

14) All applicable State and Local codes.

15) Federal, State, and local environmental requirements.

16) Uniform Federal Accessibility Standards (UFAS)

C. Mechanical Design Guides. The latest editions of the standards listed here are intended as guidelines for design and to establish a basic level of engineering practice. They are mandatory only where referenced as such in the text of this chapter, in applicable codes, or in the A-E's Scope of Work. The list is not meant to restrict the use of additional guides or standards.

1) ASHRAE: Laboratory Design Guide

2) ASHRAE: Standard 55: *Thermal Environmental Conditions for Human Occupancy*

3) ASHRAE: Standard 105: *Standard Method of Measuring and Expressing and Comparing Building Energy Performance*

4) ASHRAE: Standard 111: *Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC&R Systems*

5) ASHRAE: Standard 114: *Energy Management Control Systems*

Instrumentation.

6) ASHRAE: Standard 135: *BACnet: A Data Communication Protocol for Building Automation and Control Networks*

7) ASHRAE: Guideline 1: *The HVAC Commissioning Process*

8) ASHRAE: Guideline 4: *Preparation of Operating and Maintenance Documentation for Building Systems*

9) ASHRAE: Guideline 5: *Commissioning Smoke Management Systems*

10) ASHRAE Guideline 13: *Specifying Direct Digital Control Systems*

11) ASHRAE Applications Handbook, *Sound and Vibration Control*

12) NEBB: Procedural Standards for Building Systems Commissioning

13) American Society of Plumbing Engineers: *ASPE Data Books*

14) Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA):

    a) HVAC System Duct Design

    b) HVAC Duct Construction Standards: Metal and Flexible

    c) HVAC Air Duct Leakage Test Manual

    d) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems

    e) Seismic Restraint Manual Guidelines for Mechanical Systems

15) Energy Policy Act of 2005 (EPACT)

16) The Energy Independence and Security Act of 2007 (EISA)

17) 10 Code of Federal Regulation (CFR)

    a) Part 433 - *Energy Efficiency Standards for the Design and Construction of New Federal Commercial and Multi-Family High Rise Residential Buildings* *b)* Part 434 – *Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings*

c) Part 435 – Energy Efficiency Standards for New Federal Low-Rise Residential Buildings

D. Code Review and Analysis and Waiver Process. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that tasks accomplished during design meet code requirements. All deviations from codes/ARS requirements and any equivalency concepts proposed for use must be identified by the A-E and submitted to the Government for approval no later than the 35 percent design stage. See section 1.2.5 for requirements.

5.1.3 Design Submissions and Coordination

A. The A-E shall submit mechanical design concepts, drawings, sketches, calculations, specifications, etc. at various stages throughout the design process as outlined in the A-E contract. Refer to section 1.9, *Design Documentation* and Appendix 5A, *Mechanical Design Submission Requirements*.

B. Coordination Checklist. To ensure inter-discipline and intra discipline coordination, a review checklist is provided in Appendix 5B, *Mechanical Design Coordination Checklist*. The A-E shall make sure that all of these items, and others that pertain to good project coordination, are reviewed and addressed before submission of the documents to ARS.

5.1.4 Energy Conservation, Life Cycle Cost Analyses, and Environmental Preferred Products

A. General. A major concern in the design of a project is energy conservation and the need for all facilities to be energy efficient. For this reason, the A-E must direct attention to all areas where the greatest impact in energy savings can be made.

B. Life-Cycle Cost Analyses (LCCA). The LCCA for the HVAC requirements must be completed in conjunction with HVAC analysis that must be performed to meet EPACT 2005. EPACT 2005 requires that the design of all new Federal buildings achieve a level of energy efficiency 30 percent greater than ASHRAE Standard 90.1-2004 if life cycle cost effective. To analyze new Federal buildings, agencies must estimate both the life cycle cost and energy consumption of the planned building as designed and an otherwise identical building meeting the minimum criteria set forth by ASHRAE 90.1 - 2004. The HVAC analysis performed must meet the requirements of ASHRAE 90.1 - 2004, Appendix G, as part of the energy analysis described below.

The A-E shall perform this comparison; this analysis shall show that the planned building is designed 30 percent more energy efficient than an otherwise identical building designed to meet the requirements of ASHRAE 90.1-2004, if life cycle cost effective.

If the 30 percent savings is not life-cycle effective, the A-E must evaluate the cost-effectiveness of alternative designs at successive decrements below 30 percent in order to identify the most energy-efficient design that is life-cycle cost effective for that building. However, the building must remain compliant with the current version of ASHRAE 90.1.

The A-E shall use the life-cycle cost methodologies described in the latest edition of *Handbook 135, "Life-Cycle Costing Manual for the Federal Energy Management Program,*" published by the National Institute of Standards and Technology (NIST). The life cycle cost analysis must include investment costs, energy costs, non fuel operation and maintenance costs, repair and replacement costs, and salvage values.

C. Life-Cycle Cost Analyses (LCCA). In order to assist the A-E in meeting the new requirements for energy efficiency, several energy saving design elements are listed in the Appendix 5C *Energy Saving Design Appendix*. The items listed in the Appendix are provided to reinforce ASHRAE 90.1 requirements and stress energy saving design elements. Many of the items listed in the Appendix are also mentioned in other sections of the Chapters 5 and 7.

D. Specifying Energy Efficient Products and Equipment

1) To assist in specifying energy efficient products, the Department of Energy (DOE) provides product energy efficiency recommendations and other information at: http://www1.eere.energy.gov/femp/program/ l
2) The A-E shall specify products that are in the upper twentyfive percent of energy efficiency for all similar products, or products that are at least ten percent more efficient than the minimum level that meets Federal standards. This requirement shall apply wherever such information is available through either Federal or industry approved testing and rating procedures.

3) The A-E shall, to the greatest extent possible, incorporate energy efficient criteria consistent with ENERGY STAR and other FEMP-designated energy efficiency levels into project specifications developed for new construction and renovation. See http://www.energystar.gov/See http://www.energystar.gov/ .

4) The A-E shall specify environmentally preferable products.

E. Renewable Energy. The A-E shall incorporate the use of renewable energy technologies in the design of ARS buildings and facilities when life-cycle cost effective. Renewable energy includes photovoltaic, solar thermal, biomass (wood, wood waste, refuse and agricultural waste), wind, geothermal and low-impact hydropower technologies. Per EISA 2007, 30% of hot water demand for new buildings or major renovations must be met through the use of solar hot water heating, if life cycle cost effective.

F. Water Conservation. The A-E shall incorporate Best Management Practices (BMP) for water conservation in the design of the project. Details of these BMPs are available at Whole Building Design Guide (WBDG) Website: http://www.wbdg.org/design/conserve_water.php . Choose products labeled through the EPA WaterSense program where cost effective. The WaterSense label will indicate that these products and program meet water efficiency and performance criteria. Refer to EPA Website: http://www.epa.gov/watersense .

G. Sustainable Design. The A-E shall incorporate and apply the sustainable design principles developed for the Federal Government. These principles were developed in compliance with the requirements of the Five Guiding Principles of the High Performance and Sustainable Buildings MOU and Executive Order 13423 and have been incorporated into the internet-based "Whole Building Design Guide" that can be accessed at http://www.wbdg.org/ . Refer also to the EPA Environmentally Preferable Purchasing website at http://www.epa.gov/epp/ .

H. Meter all Utilities. Each individual building shall be metered for all utilities including electricity, water, natural gas, steam and chilled water where cost effective. Electricity, water, natural gas and steam meters shall be advanced (smart) meters with meter network connections.

5.1.5 Acoustical Requirements

A. General. Acoustical and noise level criteria for all building spaces are described in section 3.4.2 of this Manual.

B. Noise and Vibration Isolation. Refer to and incorporate the basic design techniques as described in ASHRAE *Applications Handbook, Sound and Vibration Contro*l. Isolate all rotating equipment in the building.

C. Mechanical Room Isolation. Floating isolation floors should be considered for major mechanical rooms located in penthouses or at intermediate levels in mid-rise and high-rise construction. See section 3.4.2, Class X Spaces.

D. Mechanical Chases. Mechanical chases should be closed at top and bottom, and where they enter the mechanical rooms. Any piping and ductwork should be isolated as it enters the shaft to prevent propagation of vibration to the building structure. All openings for ducts and piping must be sealed, except that shafts dedicated to gas piping must be ventilated.

5.1.6 Access to Machines and Equipment

Space shall be provided around all equipment as recommended by the manufacturer and in compliance with local code requirements for routine maintenance. Access doors or panels should be provided in ventilation equipment, ductwork and plenums as required for inspection and maintenance. Equipment access doors or panels should be readily operable and sized to allow full access. Large central equipment shall be situated to facilitate its replacement.

In addition, adequate methods of access shall be included for items such as: chillers, boilers, heat exchangers, cooling towers, reheat coils, VAV boxes; pumps; hot water heaters, and all devices which have maintenance service requirements.

The clearance required for filter and coil/tube removal shall be indicated on the drawings

Access to elevated major equipment (such as AHU's, cooling towers, chillers, and boilers) must be by stairs, not by ladders.

5.1.7 Installation of Equipment for Proper Operation

The design drawings shall show the space/installation requirements for proper performance of all equipment and appurtenances. The necessary straight upstream and downstream duct/pipe diameters shall be shown for air flow monitoring stations, sound attenuators, VAV boxes, humidifiers, duct traverse locations, hydronic flow switches, pressure reducing valves, etc.

5.2 MECHANICAL SECURITY DESIGN

5.2.1 General

A. Appropriate security design criteria and standards for a project shall be determined based on project-specific risk assessment done in accordance with the methodology outlined in the Physical Security Criteria for Federal Facilities for New Federal Office Buildings and Major Modernization Projects. (See also section 1.4, *Physical Security Design*)

B. The mechanical system should continue the operation of key life safety components following an incident. The criteria shall focus on locating components in less vulnerable areas, limiting access to mechanical systems, and providing a reasonable amount of redundancy. Mechanical system controls should remain in operation during fire conditions, although air handling units should be de-energized in accordance with NFPA requirements. Smoke control systems shall remain operational.

5.2.2 Mechanical Engineering Security Considerations

A. <u>Air System</u>

1) <u>Air Intakes</u>. Place air intakes at high level. On buildings of more than four stories, locate intakes on the fourth floor or higher. On buildings of three stories or less, locate intakes on the roof as high as practical. Locating intakes high on a wall is preferred to a roof location.

2) The design should note that laboratory exhausts are generally on the roof or upper levels of buildings and the air intakes shall be located to prevent entrainment of exhaust air.

B. <u>Utility Protection</u>

1) <u>Utilities and Feeders</u>. Locate utilities away from vulnerable areas. Utility systems should be located at least 50 feet from loading docks, front entrances, and parking areas.

2) <u>Incoming Utilities</u>. Protect incoming utilities. Within building and property lines, incoming utility systems should be concealed and given blast protection, including burial or proper encasement wherever possible (see 6.2.2.B.5)

3) Above ground backflow preventers should be enclosed and locked.

C. <u>Ventilation Systems</u>

1) <u>Smoke Evacuation</u>. Protect ventilation equipment and locate away from high risk areas. In the event of a blast, the ventilation system may be essential to smoke removal, particularly in large, open spaces. Ventilation equipment should be located away from high risk areas such as loading docks and garages. The system controls and power wiring to the equipment should be protected. The ventilation system should be connected to emergency power to provide smoke evacuation.

The designer should consider having separate HVAC systems in lobbies, loading docks, and other locations where the significant risk of an internal event exists.

Ventilation and smoke evacuation equipment should be provided with stand-alone local control panels that can continue to individually function in the event the control wiring is severed from the main control system.

2) Pressurized Stairways. Maintain positive pressure in stairways. A stairway pressurization system should maintain positive pressure in stairways for occupant refuge, safe evacuation, and access by fire fighters. The entry of smoke and hazardous gases into stairways must be minimized.

5.2.3 Fire Protection Engineering Security Considerations

A. General. The fire protection system inside the building should maintain life safety protection after an incident and allow for safe evacuation of the building when appropriate.

While fire protection systems are designed to perform well during fires, they are not traditionally designed to survive bomb blast. The three components of the fire protection system are:

1) Active features, including sprinklers, fire alarms, smoke control, etc.

2) Passive features, including fire resistant barriers.

3) Operational features, including system maintenance and employee training.

B. Active System

1) Water Supply. Protect water main. The fire protection water system should be protected from single point failure in case of a blast event. The incoming line should be encased and buried, or located 50 feet away from high threat areas. The interior mains should be looped and sectionalized.

2) Standpipe Connection. Have locked covers for standpipe connections. Locked covers should be provided on standpipe and Siamese connections to ensure reliability and prevent damage to threads.

3) Fire Alarm System. Provide microprocessor-based fire alarm system. An intelligent, microprocessor based, addressable fire alarm system with voice capability should be provided. The system should be configured so

that any single impairment shall not disable the system on more than one half of a floor. The configuration should include individual data gathering panels arranged on a network with stand-alone capability in case the main control panel is incapacitated. The system main control panel should be located in the fire control room near the building's main entrance to facilitate fire department access.

4) Egress Door Locks. All security locking arrangements on doors used for egress must comply with requirements of NFPA 101, Life Safety Code.

5.3 PLUMBING

5.3.1 Fixture Requirements

A. Fixtures shall be water conserving type. Refer to paragraph 5.1.4F. For alteration projects in the same toilet rooms or areas, fixtures shall match existing fixtures if possible. Number of fixtures in each toilet room shall conform to the National Standard Plumbing Code (NSPC) and the local plumbing code.

B. One of each types of plumbing fixtures, suitable for use by individuals with physical disabilities, shall be provided in each public toilet room (men - one lavatory, one water closet, and one urinal, women - one lavatory and one water closet.)

5.3.2 Water Coolers and Drinking Fountains

Drinking water station shall be provided near toilet rooms and shall not be provided in laboratories or where hazardous materials are stored. Drinking water station shall be suitable for use by individuals with physical disabilities. Special requirements shall be as outlined in UFAS.

5.3.3 Floor Drains

Floor drains shall be installed in boiler rooms, mechanical equipment rooms, kitchen and dishwashing areas, garages, and similar areas. Except as provided in section 7.2.13, floor drains shall not be installed in certain areas where possibilities of spills of harmful chemicals and like materials exist. Floor drains shall be provided with individual traps. Provision for automatic primers shall be made to ensure that traps for floor drains connected to sanitary sewers are sealed. Special trap depths are required for containment laboratories and animal rooms.

5.3.4 Sanitary System

A. Fixture Elevations. Each plumbing fixture and floor drain shall be installed so that the invert to the trap is not less than three feet above the top of the sewer into which it discharges. Where plumbing fixtures cannot be installed as required above, automatic sewage ejector system shall be provided.

B. Cleanouts. Refer to NSPC. Where a cleanout will interfere with architectural finish of a room, a finished brass cover shall be installed over the cleanout.

C. Sewage Ejectors. Sewage ejectors shall not be used if other methods can be employed to allow gravity flow. Where ejectors are required, only lower floor facilities shall drain to ejectors. Upper floor facilities shall drain by gravity to the main sewer. Duplex sewage pumps shall be non clog, screenless ejector type, with each discharge not less than four inches.

D. Special Wastes.

3) Acid Waste: Separate drainage and vent systems for acid wastes shall be of corrosion resistant material. Corrosive liquids, spent acids, or other harmful chemicals that might destroy or injure a drain or vent pipe, or create noxious or toxic fumes, or interfere with sewage treatment processes, shall be thoroughly diluted, neutralized, or treated prior to entering the drainage system. A properly constructed and an acceptable dilution or neutralizing device shall be provided. Depending on type of treatment required, this device shall be provided with either, or both, an automatic supply of diluting water, or a neutralizing medium, so as to make its contents safe before discharge to the drainage system. Discharge of corrosive and method of treatment shall be coordinated with and approved by local code authorities. Special isolation and sealing are required for contained mechanical equipment and devices in laboratories, animal rooms, greenhouses, etc.

4) Other Special Waste: Other special waste such as grease or oil that can enter drains shall be designed in accordance with plumbing codes.

5.3.5 Storm Water Drains

Roof drains shall be located in areas where deflection of the roofing system occurs rather than above or near columns. Locations shall be coordinated with architectural requirements. Provide cleanouts in storm water lines, as required.

5.3.6 Water Supply System

A. Water Treatment. A chemical analysis of the water supply must always be obtained. Treatment of cold water is usually not necessary where water is obtained from a municipality or from a corporation. Water softeners shall be installed, if required, for treatment of water supplied to water heaters, boilers or RO systems. Water softeners shall be installed in strict accordance with instructions from the manufacturer and applicable codes.

B. Water Piping Materials. Local engineers and water company officials should be consulted regarding the performance of different kinds of pipe in a particular locality. Dielectric couplings shall be provided where pipes of dissimilar metals are joined.

C. Water Pressures Required. Provide the minimum water pressure as required by the NSPC for the fixtures to be installed. Refer to the latest NFPA Codes and Standards for water pressure requirements for fire sprinkler and standpipe systems. When street pressures are not adequate to maintain pressures indicated above, provide a domestic water booster system..

D. Service Pipe. In large buildings, two sources of water supply from different mains are desirable. Service lines must enter the building in an accessible location. They must never enter fuel rooms, storage rooms, switchgear rooms, telecom rooms, or transformer vaults. A swing type joint shall be provided for a service line at its entrance to the building. Advanced water meters shall be provided on incoming water mains for buildings.

E. Interior Water Piping. Water distribution systems shall be protected against back flow. Refer to latest editions of the NSPC and local codes for requirements.

Pressure reducing valves shall be installed on the domestic water mains or branches where required by the NSPC or local codes. A valved bypass, one pipe size smaller than the main size, shall be provided around pressure reducing valves. The valve in the bypass shall be of the globe pattern. Specifications shall state the initial pressure, required flow, and final pressure.

F. Valves. Locations and types of valves must be shown on drawings and must be accessible. Valves shall be installed on cold water, hot water, and hot water return circulating mains so that sections of mains may be shut off without disturbing the services to other parts of the building. In addition, a valve shall be provided on the main supply at its entrance to the building and on the inlets and outlets of mechanical equipment requiring water connections. A shut off valve located close to the main shall be installed on each branch connection off the main serving more than one fixture. Valves shall be provided at the base of risers.

G. Sizing of Piping. Refer to the latest NSPC edition.

H. Domestic Hot Water. Equipment shall be automatically controlled and shall have sufficient capacity to deliver a minimum of 105 ^{o}F water. A separate domestic water heating system shall be provided to supply high temperature water requirements for special cafeteria equipment. Provide centralized controls or a local time clock to turn equipment off during unoccupied hours. The hot water maintenance method (loop or heat maintenance cable) shall be selected by life cycle cost. Fuel or energy selected for water heating shall be determined by availability and life cycle cost. Type selected maybe steam, gas, oil, electricity, or solar. The domestic hot water system shall be designed to comply with applicable codes, including ASHRAE 90.1, Paragraph 7.1. Thirty percent of the building's hot water shall be provided by solar hot water heating where cost effective.

5.3.7 Gas Piping

A. Design. Gas piping shall be designed using the latest edition of NFPA Standard No. 4 and ANSI Z 223.1, *National Fuel Gas Code*. Gas piping shall not be run in trenches, tunnels, furred ceilings, or other confined spaces where leaking gas might collect and cause an explosion. Underground piping in buildings and above ground in areas subject to fires, such as trash rooms, shall be avoided.

B. Ventilation. Gas meter rooms and places containing major gas supplied equipment, such as gas fired boilers, gas engine emergency generators, or other equipment using large quantities of gas, shall be ventilated to ensure removal of leaking gas. When major gas supplied equipment is located on upper floors or on the roof of a building, gas supply piping shall be located outside the building or in a separate two-hour fire-resistant shaft vented at the top and bottom to the outside so as to prevent leaked gas from accumulating in the shaft or penetrate other portions of the building.

C. Adequate air shall be provided for combustion in accordance with NFPA 54.

D. Advanced gas meters shall be provided on natural gas mains entering buildings.

5.3.8 Fire Safety

A. General. The requirements of the latest edition of National Fire Codes published by the National Fire Protection Association (NFPA) shall be used as criteria.

B. Automatic Sprinkler System

1) General.

a) Automatic sprinklers systems shall be installed throughout all new construction projects and in all major renovation projects in accordance with the requirements of NFPA 13 and the site applicable National Model Building Code.

b) All sprinkler systems shall be wet-pipe sprinkler systems, unless installed in areas subject to freezing or in critical areas (see paragraphs c and d below).

c) In areas subject to freezing, install dry-pipe sprinkler systems, dry pendent sprinkler systems, or provide heat in the space, and/or reroute the sprinkler piping. Heat tape shall not be used on sprinkler piping.

d) Preaction sprinkler systems should be used for some critical areas where an accidental sprinkler discharge can cause serious water damage.

2) Sprinkler System Design. Sprinkler systems shall be hydraulically calculated in accordance with the requirements specified in NFPA 13.

C. Some critical areas may require fire protection by systems other than wet sprinkler systems. An example of this type of area is a computer room. For these areas, provide dry chemical fire suppression systems. Systems using Halon are prohibited.

5.4 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

5.4.1 Design Criteria

A. General. Comfort conditions to be maintained in a building are dry bulb temperature and relative humidity, three to five feet above the floor. Designed indoor temperature will vary with the activity and intended use of the building.

B. Outdoor Design Conditions. Outdoor air design criteria shall be based on weather data tabulated in the latest edition of the ASHRAE Handbook of Fundamentals. Winter design conditions shall be based on the 99 percent column dry bulb temperature in the ASHRAE table. Summer design conditions shall be based on the one percent column dry bulb temperature, with its corresponding mean coincident wet bulb temperature. Cooling towers shall be selected based on the one percent wet-bulb temperature.

C. Indoor Design Conditions. Unless otherwise specified in the project's POR, the following indoor design conditions shall be used to calculate loads and size of equipment:

1) General Office Space and Laboratories Cooling 76 ^{o}F DB and 50 percent RH Heating 70 ^{o}F DB and a minimum of 30 percent RH.

2) Computer Rooms Year-round 72 ^{o}F to 78 ^{o}F and 40 percent RH.

5.4.2 Design Calculations

A. Heat Losses. Heat losses shall be calculated in BTU per hour. Heat transfer coefficients and calculations shall be based on the ASHRAE Handbook of Fundamentals. The heating plant shall be sized based on the calculated block heating load for space and process plus an allowance of 25 percent extra capacities per ASHRAE 90.1.

B. Heat Gains. Heat gains shall be calculated in BTU per hour. Heat transfer coefficients and calculations shall be based on the ASHRAE Handbook of Fundamentals. Unless otherwise specified in the project POR, cooling load calculations shall be based on inside design conditions of 76 ^{o}F DB and 50 percent RH.

The refrigerating plant shall be sized based on the calculated block cooling load plus an allowance of 15 percent extra capacities, per ASHRAE 90.1.

C. Calculation Format.

1) Calculations shall be recorded in a standard format for each room to permit checking and to provide a reference for system modification. Design calculations shall include, but not be limited to, indoor and outdoor temperatures, heat loss, heat gain, supply and exhaust ventilation requirements, humidification or dehumidification requirements, and heat recovered.

2) The room heating and cooling loads shall include a 10 percent safety factor.

5.4.3 HVAC Design Coordination

HVAC design shall be coordinated with other facets of construction. The following factors require special consideration.

A. Mechanical Equipment Rooms. Rooms shall provide adequate space for equipment installation and maintenance. If expansion is planned, the size shall be based on future requirements. Equipment removal access shall be provided where required. Proper location of these spaces is necessary for economical air and water distribution.

B. Shafts. Size and location of shafts for ductwork and pipes shall be checked before ductwork and piping system design. Effects of shaft location on mechanical equipment and distribution systems shall be carefully determined.

C. Louvers. Location and size of outdoor air intakes, relief air discharge, and exhaust air discharge louvers shall be coordinated with the architectural design. Outdoor air intakes shall be located so as to avoid intakes of dust, smoke, generator and truck diesel fumes and exhaust air.

D. Cooling Tower Location. Tower shall be located so as to be least obvious and, if possible, at ground level. Discharge at low levels, or where it may come in contact with buildings or fresh air intakes, shall be avoided

E. Access. Location and size of control panels and the type of service and maintenance a facility requires shall be coordinated with the architectural design to allow personnel access to an area or to a piece of equipment.

F. Wind Forces. Design of outdoor equipment, such as cooling towers, stacks, and their supports, shall be based on the maximum wind velocities prevalent at the site. Exterior mechanical equipment shall be anchored, braced or guyed to withstand the prevailing wind velocity.

G. Seismic Considerations. If sites are subject to earthquakes, design of equipment especially outdoor cooling towers and water tanks, piping systems, ductwork, and foundations, shall include suitable allowance for horizontal forces. Equipment and piping shall be seismically braced.

5.4.4 Ventilation and Exhaust Requirements

A. Ventilation shall be provided as required to remove hazardous or noxious fumes for dust and odor control, equipment room temperature control, and for personnel comfort.

1) Important ventilation criteria are in Chapter 7, *Safety and Health Elements*. This chapter must be consulted.

2) Laboratories: In addition to the Chapter 7 requirements, ventilation

systems shall be designed to comply with NFPA 45 and ANSI Z9.5, American National Standard for Laboratory Ventilation, and the ASHRAE *Laboratory Design Guide*.

3) Non-Laboratory spaces: Ventilation systems shall comply with ASHRAE Standard 62.1, *Ventilation for Acceptable Indoor Air Quality*. Where appropriate, process ventilation shall conform to the American Conference of Governmental Industrial Hygienists publications and recommendations.

4) Laboratory and hazardous fume exhaust: For laboratory exhaust and other systems conveying hazardous fumes, an exhaust plume analysis shall be performed. This analysis will verify that the exhausted air does not re-enter the building's fresh air intake or the intakes of nearby buildings or otherwise pose a hazard to personnel.

5) For the design and testing requirements of laboratory fume hoods, refer to Chapter 7.

B. Spaces where exhaust systems are used to remove contaminated or hot air shall be maintained at a negative pressure to prevent exfiltration to other areas. Negative pressure shall be created by exhausting five to 15 percent more air than the supply air. If anticipated fumes and vapors have a specific gravity greater than air, exhaust intakes shall be provided at the floor level.

C. Explosion proof ventilation equipment shall be provided for areas where explosive vapors or dust are anticipated.

D. Filters shall be provided where particulate matter must be removed from the supply or exhaust air.

5.4.5 Air Cleaning Systems

Air supplied to occupied spaces, equipment rooms, kitchens, cafeterias, etc., shall be provided with air filters, arranged to provide clean air at an upstream side of air handling units, fan coil units, and heating units. Filter efficiency shall be in accordance with ASHRAE recommendations. Select filters for operating velocity recommended by the manufacturer to give an economic combination of static pressure loss and dust holding capacity. Minimum clearance of two feet shall be provided for service and inspection. An access door with minimum width of 18 inches and an electric light in a watertight type fixture shall be provided.

5.4.6 Piping Systems

Design piping per ASHRAE Handbook of Fundamentals. Provide valves to isolate equipment (for operation and repair), including room units and individual risers to room units. Provide bypass piping on critical systems to allow operation during maintenance operations that may have extended times. Provide manual vents at high points and hose type drain valves at low points and both in sections or risers that can be isolated by valves. Show locations of expansion joints, loops, and anchors on drawings.

Suitable devices shall be provided so flow can be measured in major equipment such as chillers, cooling towers, boilers, AHU coils, solar system loops, or other zones; e.g., primary and secondary loops. Balancing devices shall be provided to allow adjustment. Cooling towers shall be equipped with water meters where sewer charges may be avoided on makeup water.

Piping systems shall be insulated as required for the service and location in the building and in accordance with ASHRAE 90.1. Systems exposed to weather or in tunnels shall be protected from freezing. Each closed/open piping system shall be provided with chemical treatment to inhibit corrosion, bacterial scale, deposits, or growth.

Equipment in corrosive environments such as marine areas shall be corrosion resistant.

5.4.7 Air Duct Systems

A. Equal friction method or static pressure regain method in the ASHRAE *Handbook of Fundamentals* may be used to determine duct sizes.

B. Duct leakage rates shall be per AHSRAE *Handbook of Fundamentals*. The SMACNA duct seal classifications shall be shown on the drawings. (Note: For facilities involving work with hazardous materials, all ducts shall be constructed in a leak tight manner with seams and joints usually welded airtight.)

C. Where ductwork is connected to equipment (such as heating coils, cooling coils, or filters), transition fittings should be smooth. Slopes of transition shall be 15 degrees on the upstream side and less than 30 degrees on the downstream side. Transitions in elbows shall be avoided.

D. Access doors or panels shall be provided in ductwork for any apparatus requiring maintenance, inspection, and service for: filters; cooling coils; sound absorbers; volume and splitter dampers; fire dampers; thermostats; temperature controls; variable air volume boxes; valves; and humidifiers.

E. Volume or splitter dampers shall be provided in ductwork, where necessary, to obtain proper control, balancing, and distribution. Fire and smoke dampers shall be provided in accordance with NFPA standards. (NOTE: No dampers shall be used in chemical fume hood exhaust ductwork.)

5.4.8 Air Distribution Devices

Air outlets shall be selected and located to provide proper throw, drop, and spread. Air should not blow against obstructions such as beams, columns, lights or sprinklers, or on occupants. Supply outlets shall be uniformly located within range of throws to distributed loads with air velocity at the occupant's level not exceeding 50 feet per minute. Where loads are concentrated, supply outlets shall be located near the load source. Noise level criteria shall be included on the drawing schedule.

Supply air diffusers shall be placed so as not to interfere with the function of fume hoods. Supply air diffusers and exhaust inlets shall be placed so that the room is swept by the air with short circuits being avoided. See section 7.2.2.

Air terminals for variable air volume (VAV) systems shall be selected to be compatible with characteristics of VAV box; i.e., outlets must be capable of performing at full and partial loads. Flow patterns must be properly evaluated. Standard air outlets do not perform satisfactorily with variable air volume flows.

5.4.9 Equipment Selection

A. Fans. Fans shall be selected to operate as close to the point of maximum efficiency as possible. Fans should absorb the least brake horsepower for the given conditions of air flow and static pressure. If fans are selected for parallel operation, each fan shall have self closing or automatic discharge dampers to prevent back flow.

   Fan motors shall be sized for individual operation with increased air flow against reduced static pressure.

B. Central System Air Handling Unit Requirements. Psychometric analysis, with load calculations shall be provided for each air handling system in accordance with ASHRAE procedures. Face velocity for coils and filters shall be between 400 - 500 feet per minute.

C. Refrigerating Machines. Refrigerating units in a plant should be of the same type. Design plant for minimum of two units that will carry the load and provide sufficient capacity reduction to permit continuous operation at minimum loads. Variable frequency drives on centrifugal chillers should be provided for energy conservation.

   Arrange condensers and chillers for parallel flow unless series flow of chilled water is proved more economical. Flow diagrams must be provided coordinating flow and temperature ranges of chillers and cooling coils; include hydraulic characteristics of the chilled water system and pumps. Machines selected shall be energy conserving. Energy consumption per ton kW/hr shall be specified; however, the kW requirements must be met by more than two major manufacturers.

Consider variable frequency drives on parallel pumping operations to equalize flow and overcome the different friction loses during both 1 pump and 2 pump operations.

D. Cooling Towers. Provide mechanically induced draft cooling towers having a separate cell for each refrigerating machine. Each cell shall have a separate basin. Height of supports should permit easy maintenance and painting of basin and supporting structure. Outlet connections must be accessible for repairs. Variable frequency drives on cooling towers should be provided for energy conservation.

Size towers for heat rejection of system served with a 10 ^{o}F water temperature rise and an approximately 8 ^{o}F approach to entering wet bulb temperature. Design architectural enclosures and structural supports to accommodate both cross flow and counter flow towers having any standard post spacing. Enclosures should not restrict air flow to tower or permit recirculating of fan discharge air.

Consider a three way valve configuration to provide constant condenser water temperature return to the chiller. Controls and programming for lowering condenser water temperatures on low load days should be considered for better chiller efficiency.

E. Boilers. Multiple boilers should be of the same type. Design plant for minimum of two units that will carry the load and provide sufficient capacity reduction to permit continuous operation at minimum loads. Boilers shall be sized to maximize efficiency.

Central steam shall be used as the heating source if available and life cycle cost efficient. Building level advanced steam meters shall be installed and connected to the meter network.

5.4.10 Automatic Temperature and Humidity Control

A. General. Automatic controls for temperature and humidity shall be provided for HVAC systems and shall comply with ASHRAE 90.1, specifically Paragraph 6.4.3.

Drawings shall delineate the control type, with standard symbols, schedules, description of operation, sequences, throttling ranges, set points, alarms, etc. Show all room thermostats/sensors on floor plans.

B. Direct Digital Control (DDC) system with a host computer controlled monitoring and control shall be provided.

1) Controls. Preprogrammed stand-alone single or multiple loop controllers shall be used to control all HVAC and plumbing subsystems. DDC computers shall have USDA security software.

2) Temperature Controls. Heating and cooling energy in each zone shall be controlled by a thermostat or a temperature sensor located in that zone. Independent perimeter systems must have at least one thermostat or temperature sensor for each facade of the building with a different orientation.

The sequences controlling the heating and cooling to spaces shall minimize the magnitude to which they are provided simultaneously. A 2.5°C (5°F) deadband shall be used between independent heating and cooling operations within the same zone.

Night set back 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 must be part of the control system. Occupancy sensors must be provided for laboratories.

C. Temperature Reset and Economizer Controls for Air Systems. Where appropriate, systems supplying heated or cooled air to multiple zones will include controls that automatically reset supply air temperature by representative building loads or by outside air temperature. Where required by ASHRAE 90.1, an economizer cycle will be used when the outside air conditions can provide free cooling Refer to Paragraph 5.1.4.

D. Hydronic Systems. Where appropriate, systems supplying heated water to comfort conditioning systems will also include controls that automatically reset supply water temperatures by representative temperature changes responding to changes in building loads (including return water temperature) or by outside air temperature. Consideration shall be given to resetting condenser water supply to chillers. to Paragraph 5.1.4 and resetting discharge air to minimize reheat (simultaneous heating and cooling).

5.4.11 Start-up, Testing, and Balancing Equipment and Systems

A. Start-up. The designer shall specify that factory representatives are present for startup of all major equipment, such as boilers, chillers and automatic control systems.

B. Testing and Balancing. It shall be the responsibility of the designer to adequately specify testing, adjusting and balancing resulting in not only proper operation of individual pieces of equipment, but also the proper operation of the overall HVAC system (air and water sides) in accordance with the design intent. The Testing and Balancing contractor shall have up to date certification by either Associated Air Balance Council (AABC) or National Environmental Balance Bureau (NEBB). The specification shall adequately address both occupied and unoccupied operations and seasonal conditions if applicable. Airflow or air balance diagrams shall be included to simplify testing and balancing operations. The TAB contractor shall be a first tier sub to the general contractor.

C. Commissioning. The designer shall prepare contract documents which include provisions for commissioning of the mechanical, plumbing, and fire protection systems.

The specification shall adequately address both occupied and unoccupied operations and seasonal conditions if applicable. Airflow or air balance diagrams shall be included to simplify testing and balancing operations.

5.5 UNDERGROUND HEAT AND CHILLED WATER DISTRIBUTION SYSTEMS

5.5.1 General

Underground heat and chilled water distribution systems shall be designed in accordance with the ASHRAE Handbook Series and standard industry practice.

Advanced steam meters shall be provided on steam mains entering buildings where cost effective. Meters are required when steam is supplied from a central or off- site boiler plant.

Meters for chilled water shall be provided for chilled water mains entering buildings where cost effective. Meters are required when chilled water is supplied from a central or off- site chilled water plant.

Appendix 5A: Mechanical & Plumbing Design Submission Requirements

5A-1 15 Percent Mechanical Design Submittal

This submittal stage is required on the more complex projects, and/or where mechanical design elements are required to obtain coordinated interior design development, or development of exterior design considerations.

A. Drawings.

1) Plans showing equipment spaces for mechanical equipment, fire protection systems (e.g., fire pump, fire alarm, etc.), fire protection water supplies, fire hydrant locations, fire apparatus access roads, and fire lanes.

B. Narrative.

1) Description of the potential HVAC systems.

2) Description of the building's proposed fire protection systems.

3) Proposed special features of plumbing system.

4) List of applicable codes and code compliance statements.

5A-2 Conceptual Mechanical Design Submittal

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Block loads for heating and cooling.

3) Life cycle cost analysis.

4) Provide a narrative to describe all HVAC systems that shall include but is not limited to, laboratory systems, office air systems, chilled water, and heating systems.

5) Description of the enhanced energy conservation measures that exceed the

requirements of ASHRAE 90.1-2004.

6) Description of water conservation measures.

7) Description of hot water solar power to meet 30% requirement if life cycle cost effective.

8) Preliminary controls strategy narrative.

9) Environmental considerations and permitting requirements.

10) Response to 15% review comments.

B. Drawings and Specifications

1) Locations of mechanical rooms, fresh air intakes and exhaust locations.

2) Single line duct drawings showing preliminary sizes of the main.

3) Preliminary details and schedules.

4) List of specifications to use with short description of content.

C. Design A-E Checklist

5A-3 35 Percent Mechanical Design Submittal

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Block loads for heating and cooling.

3) Life cycle cost analysis.

4) Provide a narrative to describe all HVAC systems that shall include but is not limited to, laboratory systems, office air systems, chilled water, and heating systems.

5) The energy comparison analysis between the ASHRAE 90.1-2004 building and the designed building.

6) Description of water conservation measures.

7) Description of hot water solar power to meet 30% requirement if life cycle cost effective.

8) Preliminary controls strategy narrative.

9) Environmental considerations and permitting requirements.

10) Response to 15% review comments.

B. Drawings and Specifications

1) Locations of mechanical rooms, fresh air intakes and exhaust locations.

2) Single line duct drawings showing preliminary sizes of the main.

3) Preliminary details and schedules.

4) List of specifications to use with short description of content.

C. Design A-E Checklist

5A-4 50 Percent Mechanical Design Submittal

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Narrative Description of HVAC systems.

3) Block and Room Loads for heating and cooling.

4) Final description of energy conservation measures and final energy comparison analysis.

5) Preliminary equipment selection for major equipment (chillers, cooling towers, AHU’s, exhaust fans, pumps, VAV boxes, etc.).

6) Controls strategy narrative.

7) Preliminary duct and pipe sizing calculations.

8) Preliminary laboratory exhaust plume analysis.

9) Response to 35% review comments.

B. Drawings and Specifications.

1) Sequences of control.

2) Air flow diagrams, including balancing information.

3) Marked-up specifications.

4) Preliminary details and schedules.

5) Double line duct drawings for mechanical rooms and duct mains.

6) Single line duct drawings for branch ducts.

7) Locations of mechanical rooms with equipment drawn to scale.

8) Locations of fresh air intakes and exhaust locations.

9) Duct and piping system schematic.

C. Design A-E Checklist

5A-5 95 Percent Mechanical Design Submittal

A. Design Analysis.

1.) Any revisions from the 50 percent submittal.

2.) Narrative description of HVAC systems.

3.) Final equipment selections showing two manufactures.

4.) Final laboratory exhaust plume analysis.

5.) Duct and pipe size analysis.

6.) AHU psychometric analysis.

7.) Responses to the 50 percent Review Comments.

B. Drawings and Specifications

Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

5A-6 100 Percent Mechanical Design Submittal

A. Design Analysis.

1) Complete Design Analysis incorporating the final calculations, narrative, equipment selections, final completed A-E Design Checklist, review comments etc.

2) Responses to the 95 percent Review Comments.

B. Drawings and Specifications

Complete drawing and specification package suitable to "Issue for Bidding and Construction".

5A-7 Conceptual Plumbing Design Submittal

A. Design Analysis

2) Listing of applicable codes and code compliance statement.

3) Response to 15% review comments.

4) Narrative description of the proposed plumbing systems, including the following:

a) Supply water availability, quality, and pressure.

b) Fixture count analysis.

c) Description of any special treatment systems for both supply and waste.

d) The results of any water testing, including water quality and fire hydrant flow tests.

e) Environmental considerations and permitting requirements.

B. Drawings and Specifications

1) Locations of mechanical rooms, water and sewer mains.

2) List of specifications to use with short description of content.

C. Design A-E Checklist

5A-8 35 Percent Plumbing Design Submittal

A. Design Analysis

5) Listing of applicable codes and code compliance statement.

6) Response to the 15 percent review comments.

7) Narrative description of the proposed plumbing systems, including the following:

a) Supply water availability, quality, and pressure.

b) Fixture count analysis.

c) Description of any special treatment systems for both supply and waste.

d) The results of any water testing, including water quality and fire hydrant flow tests.

e) Environmental consideration and permitting requirements.

B. Drawings and Specifications

1) Locations of mechanical rooms, water and sewer mains.

2) List of specifications to use with short description of content.

C. Design A-E Checklist

5A-9 50 Percent Plumbing Design Submittal

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Narrative Description Plumbing systems.

3) Preliminary equipment selection for major equipment (sewage treatment, domestic water treatment, etc.).

4) Preliminary calculations for water supply, storm and sewer piping.

5) Response to the 35 percent review comments.

B. Drawings and Specifications.

1) Sequences of control.

2) Riser diagrams and schematics.

3) Marked up specifications.

4) Preliminary schedules.

5) Locations of mechanical rooms with equipment drawn to scale.

C. Design A-E Checklist

5A-10 95 Percent Plumbing Design Submittal

A. Design Analysis.

1) Any revisions from the 50 percent submittal.

2) Narrative description of plumbing systems.

3) Final equipment selections showing two manufactures for each piece of equipment.

4) Piping sizing analysis.

5) Duct and pipe size analysis.

6) Responses to the 50 percent review comments.

B. Drawings and Specifications

Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

5A-11 100 Percent Plumbing Design Submittal

A. Design Analysis.

1) Complete Design Analysis incorporating the final calculations, narrative, equipment selections, final completed A-E Design Checklist, review comments etc.

2) Responses to the 95 percent review comments.

B. Drawings and Specifications

Complete drawing and specification package suitable to "Issue for Bidding and Construction".

Appendix 5B: Mechanical Design Coordination Checklist

5B-1. General

A. Interference with structural framing members coordinated.

B. Equipment pad locations coordinated with structural drawings.

C. Adequate clearances to service and replace mechanical equipment.

D. Hoists (or other means of equipment replacement) coordinated with structural drawings.

E. Motors and special power needs coordinated with electrical drawings.

F. Location of roof drains and floor drains coordinated with architectural and structural drawings.

G. Air diffusers and registers coordinated with architectural drawings and electrical lighting plans.

H. Location of supply and exhaust systems coordinated with security barriers, detection devices and other related concerns.

I. Louver sizes and locations coordinated with architectural drawings.

J. Inverts of piping coordinated with civil drawings.

K. Supports and bracing for major piping, ductwork and equipment coordinated with structural drawings.

L. Penetrations through rated walls/floor/roof assemblies detailed and specified.

M. Building Automation System specified, including software and point schedules.

N. Start up and testing requirements specified.

5B-2. Special Checklist for VAV Systems

A. For administrative/office VAV Systems: Minimum amounts of outside air to be admitted during occupied hours shown on drawings; also, minimum ventilation supplied at lowest setting of VAV boxes. Administrative VAV systems shall be designed to minimize reheat by turning down supply air when heating is required, i.e., airflow will be at minimum rates when heating is required.

B. Fan schedules for both supply and return fans, showing minimum and maximum airflow rates and total pressure at minimum flow, maximum sound power level and blade frequency increment at peak air flow.

C. VAV terminal units to be specified indicating maximum and minimum air flow rates minimum static pressure required, maximum static pressure permitted and noise ratings at maximum air flow.

D. Supply air outlets specified by face and neck sizes, performance for maximum and minimum airflow.

E. Controller pressure setting and sensor location shown, including reference pressure location. For multiple sensors all locations must be shown. Also, show pressure setting for high limits of supply fans.

F. Maximum and minimum air flow rates shown for air flow measuring stations. Air flow measuring stations located.

G. All required control instruments shown and located.

5B-3. Fire Protection Review Checklist

A. Building Construction

1) Verify details for fire walls and smoke partitions.

2) Verify fire stopping for penetrations in fire rated walls and floors meet Code requirements.

3) Verify structural components are fire rated (if applicable).

4) Verify fireproofing meets Code requirements (if applicable).

5) Verify proper building separation for exposure protection.

6) Verify interior finish meets Code requirements.

B. Life Safety

1) Verify the number of exits based on occupant loads.

2) Verify exits discharge outside.

3) Verify travel distance to exits.

4) Verify remoteness of exits.

5) Verify common paths of travel limits meet Code requirements.

6) Verify door swings meet Code requirements.

7) Verify stair details.

8) Verify horizontal exit details.

9) Verify exit signs meet Code requirements.

10) Verify emergency lighting meets Code requirements.

11) Verify each occupancy classification meets specific exiting requirements.

12) Verify the type, size, and location of each portable fire extinguisher.

C. Water Supply

1) Verify water supply is adequate to meet design density.

2) Verify location of valve box and cover plate on buried gate valves.

3) Verify fire pump calculations justify the size of the fire pump and jockey pump.

4) Verify riser diagram for fire pump meets Code requirements.

5) Verify detail of fire pump configurations.

6) Verify sensing lines for both the fire pump and jockey pumps are indicated on the details.

7) Verify all piping for fire pumps is identified on the drawings.

8) Verify the location of the test header.

9) Verify the location of both controllers.

10) Verify the power feeds to the fire pump and jockey pumps are identified on the drawings.

D. Water-based Fire Extinguishing Systems

1) Verify specifications contain information stating the static and residual pressures are available at a measured flow rate.

2) Verify the sprinkler riser is sized properly on the riser diagrams.

3) Verify that sprinkler piping is not shown on the construction contract drawings. Only the interior fire main piping shall be shown, in addition to the location of obstructions, structural components, walls, floors, and ceilings.

4) Verify the location and size of underground or standpipe water supplies.

5) Verify the location and arrangement of all water flow and tamper switches.

6) Verify the location of the riser and all points where it penetrates a floor.

7) Verify the location of the fire department connection.

8) Verify the location of all control valves and alarm valves.

9) Verify all areas of the building have sprinkler protection.

10) Verify accuracy of symbol lists.

11) Verify all floor control valves and sectional valves have drains.

12) Verify inspector’s test valve arrangement.

13) Verify wall and ceiling construction is indicated, as well as ceiling height.

E. Non-Water-Based Fire Extinguisher Systems

1) Verify kitchen equipment is protected by a wet chemical system, monitored by fire alarm system.

2) Verify power and gas shut down for kitchen equipment meet Code requirements.

3) Verify locations of all fire fighter telephone stations and telephone jacks on the drawings and riser diagram meet Code requirements.

4) Verify locations of all duct smoke detectors on the drawings and riser diagram meet Code requirements.

5) Verify accuracy of fire alarm system input/output matrixes.

6) Verify accuracy of symbol lists.

7) Verify accuracy of final smoke control calculations where applicable (e.g., atriums, etc.)

8) Verify accuracy of final stairway pressurization calculations where applicable.

9) Verify accuracy of the interface of fire alarm system and Building Automation System.

10) Verify accuracy of the interface of fire alarm system and the building security systems.

F. Miscellaneous

1) Verify that the locations of the fire dampers meet Code requirements.

2) Verify that the locations of smoke dampers meet Code requirements.

3) Verify that the elevator systems meet Code requirements.

4) Verify that sprinklered elevator machine rooms are provided with a means to automatically disconnect power.

G. Fire Alarm System

1) Verify location of all audible notification appliances on the drawings and

riser diagram meet Code requirements.

2) Verify audible notification appliances are identified in stairways and elevator cabs.

3) Verify location of all visible notification appliances on the drawings and riser diagram meet Code requirements.

4) Verify accuracy of fire alarm riser diagrams.

5) Verify that at least two vertical fire alarm risers are installed as remote as possible from each other. Verify that the second riser is separated from the first riser by at least a one-hour fire rated enclosure, not common to both risers.

6) Verify location and construction requirements of fire command centers.

7) Verify location of graphic annunciator panels.

8) Verify fire alarm system wiring is solid copper.

9) Verify location of all manual fire alarm stations meet Code requirements.

10) Verify smoke detectors are installed in each elevator lobby and elevator machine room to initiate elevator recall.

11) Verify locations of all area smoke and heat detectors on the drawings and riser diagram meet Code requirements, including detectors for HVAC systems.

5B-4. Data and Operations Manual

An operations manual shall be prepared and training provided for the building Operations and Maintenance personnel describing the design objectives and how to operate the building. Make a video recording of the training. The manual shall include as-built drawings, equipment data, model numbers for the equipment, parts lists, equipment options, operating manuals for each piece of equipment, testing and balancing reports and certifications, maintenance schedules, and warranty schedules. This manual must also diagram the cabling, fire safety sprinkler system, and exterior grounds sprinkler system. The manual must be reviewed and certified complete before submission to the Facilities Manager. Arrange by spec section.

Appendix 5C: Energy Saving Design Appendix

In order to assist the A-E in meeting the new requirements for energy efficiency, several energy saving design elements are listed below. Note that the design shall incorporate the minimum requirements of AHSRAE 90.1, 2004. The items listed below are provided to reinforce ASHRAE 90.1 requirements and stress energy savings. Many of the items listed below are also mentioned in other sections of the Chapters 5 and 7. The following energy saving design elements are to be implemented if life cycle cost effective, as determined by computer modeling simulation. Items that are not life cycle cost (LCC) effective, but can be considered "borderline", shall be considered for implementation on a case-by-case basis by the design team based on project priorities.

Items that must be included in the design, if LCC effective, are listed below:

1) Variable Air Volume (VAV) laboratory airflow. Note that Constant Air Volume (CAV) can be used in smaller buildings and in some climate zones as allowed by ASHRAE 90.1. Reference ASHRAE 90.1, Paragraph 6.5.7.2, for using VAV systems.

2) Laboratory occupancy sensors. Reference ASHRAE 90.1, Paragraph 6.4.3.3.1.

3) Energy efficient lighting – All lighting shall be energy efficient. Use T5/T8 bulbs with electronic ballasts, LEDs, occupancy sensors for lighting control, etc. Refer to Chapter 6. Reference ASHRAE 90.1, Paragraph 6.5.1.1. Use compact fluorescent lamps for recessed fixtures. Regular medium screw base incandescent lamps, Mercury HID and Probe Start Metal Halide lamps shall not be used.

4) Airside economizer cycles for recirculating air handling units (office space). Reference ASHRAE 90.1, Paragraph 6.5.1.1.

5) Energy Recovery – Reference ASHRAE 90.1, Paragraph 6.5.6.1.

6) Multiple boiler and chiller installations to maximize equipment part load efficiencies.

7) Chilled and heating hot water temperature reset. – Reference ASHRAE 90.1, Paragraph 6.5.4.3.

8) Condenser Water Reset.

9) Variable speed drives on centrifugal chillers.

10) Variable speed drives on cooling tower fans (to be used in conjunction with condenser water reset). Reference ASHRAE 90.1, Paragraph 6.5.5.2.

11) Waterside economizers – use of cooling tower water in a heat exchanger or directly as chilled water during cold weather. Reference ASHRAE 90.1, Paragraph 6.5.1.2.

12) Low Pressure Drop HVAC Design – Note this is also in the next category at a more defined level, but this energy saving design feature is required to meet the fan power limitations of ASHRAE 90.1. Reference ASHRAE 90.1, Paragraph 6.5.3.1.

13) Variable pumping systems – chilled, condenser, heating hot water systems. Reference ASHRAE 90.1, Paragraph 6.5.4.1.

14) Demand control ventilation in recirculating AHUs. Reference ASHRAE 90.1, Paragraph 6.4.3.8.

15) The design shall incorporate HVAC system Optimization in the HVAC design and programming requirements. This includes maximizing the energy efficiency of the heating and chilled water systems. Some items are listed below. Reference ASHRAE 90.1, Paragraph 6.4.3.2.3.

   a. Maximize boiler staging.

   b. Optimize chiller plant operation – both chillers and cooling tower. Weigh cycling cooling tower fans vs. lowering condenser water temperature to chiller. Sequence chillers to maximize part load efficiencies.

   c. Supply fan pressure optimization.

   d. “Right Size” Equipment – heating, cooling, fans, pumps, etc.

   e. Control system optimization – appropriate set points for winter/summer conditions – temperature and pressure sensors, proper deadband, correct settings of VFD drives, etc.

Items that should be considered for the design, if LCC effective, are listed below. This list is provided to assist the designer in reducing energy consumption by a total of 30 percent over ASHRAE 90.1.

1) Five foot fume hoods (in lieu of six foot hoods) – Must have approval of the Program Director.

2) Minimize reheat (using dual ducts, outside air reset to vary supply air, supplemental cooling, chilled beams, etc.)

3) Reset supply air temperature to suit space conditions. Consider multiple supply air temperatures based on seasonal requirements.

4) Energy Recovery Heat Wheels for HVAC systems that meet NFPA 45 requirements.

5) Energy Recovery utilizing pre-cooling of outside air.

6) Supplemental Cooling/Chilled Beams as a means to minimize conditioning outside air to meet lab cooling requirements. The intent is to keep air changes at eight per hour regardless of the lab cooling requirements.

7) Low pressure drop HVAC design. Additional pressure drop reductions to be considered, including using oversized duct, minimizing attenuation, using low pressure control devices, and low face velocity AHUs.

8) Combination fume hood sashes – slides both horizontally and vertically, reducing the airflow needed to maintain 100 FPM at sash openings (effectively reducing the size of the sash opening.

9) Day lighting with automatic lighting control. Refer to Chapter 6.

10) Automatic Sash Closures.

The following items should also be considered, if LCC effective, in order to take advantage of a project's unique features:

1) Ground source heat pumps for smaller HVAC systems.

2) Condensing modular boilers for low heating load systems.

3) Desuperheater water heaters using heat recovery from refrigeration systems.

4) Condensing water heaters.

5) Solar hot water heaters.

6) Other unique design features suitable for the specific geographic areas – i.e. using geothermal sources for heating and/or cooling.

6. ELECTRICAL SYSTEMS

6.1 GENERAL

6.1.1 Scope

This Chapter presents data and considerations necessary for proper selection and design of electrical systems. This chapter covers load estimating factors, electrical power sources, distribution systems, illumination, communication, signaling, special equipment, and repair and alterations for ARS buildings and facilities.

6.1.2 Codes and Standards

A. The design shall comply with the requirements of the applicable codes and standards that apply to electrical system design. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the project's design and construction. See Chapter 1: *Basic Requirements* for complete discussion of codes and other special requirements

B. Electrical Standards. All electrical and communications systems shall meet or exceed the requirements of NFPA 70: National Electrical Code (NEC).

C. Code Review and Analysis and Waiver Process. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that the design meets code requirements. All deviations from code and ARS requirements, and any equivalency concepts proposed for use, shall be identified by the A-E and submitted to the Government for approval no later than the 35 percent design stage. See section 1.2.5 for requirements.

6.1.3 Design Submissions and Coordination

A. The A-E shall submit electrical design concepts, drawings, sketches, calculations, specifications, etc. at various stages throughout the design process as outlined in the A-E contract. Refer to section 1.8, *Design Documentation* and Appendix 6A, *Electrical Design Submission Requirements* for required content at each level of submission.

B. Coordination Checklist. To document inter-discipline and intra discipline coordination, a review checklist is provided in Appendix 6B, *Electrical Design Coordination Checklist*. The A-E shall assure that all of these items, and others that pertain to good project coordination, are reviewed and addressed before submission of the documents to ARS. To assist in coordination, the A-E shall also complete the A-E Design Checklist, a copy shall be provided to the EPM.

6.1.4 Economic Design

A. General. Electrical systems shall be designed and documented to permit acceptable competitive bids. Equipment and systems shall be efficient and economical in construction, operation, and maintenance. The distribution system shall be designed to minimize the installed cost without effecting spare capacity and future expansion. The location of loads shall be evaluated when designing the distribution system.

B. Circuiting. To avoid excessive initial cost, keep the number of feeder and branch circuits to a minimum without compromising the final size of the conductors or voltage drop of any circuits.

C. Economic Analysis. The A-E shall perform an economic analysis of power sources, distribution equipment and utilization voltages to determine the optimum power distribution scheme. The following factors shall be considered:

1) Primary versus secondary revenue metering.

2) Government-owned versus electric utility-owned transformers.

3) Use of medium-voltage motors for large equipment, such as compressors, pumps, and chillers.

4) Frequency of service interruptions to the extent that they affect the facility.

5) Costs for equipment replacement and additions.

6) Individual versus combined revenue metering.

7) Cost of power factor correction capacitors where rate schedules penalize a low power factor.

6.1.5 Energy Conservation, Life Cycle Cost Analyses and Environmentally Preferable Products

A. General. A major concern in the design of a project is energy and water conservation and the need for all facilities to be energy efficient. For this reason, the A-E must direct attention to all areas where the greatest impact in energy savings can be made.

The A/E shall incorporate sustainable design practices in the design of all facilities including energy conservation measures. The electrical designer shall utilize the current edition of ASHRAE/IES 90.1 as the basis for energy conservation design. Use life cycle cost analysis to determine the viability and capital costs for energy efficient design options.

One of the largest energy consumers in a building is the lighting system. The overall efficiency of the lighting system depends both on the individual components and on the interaction of components in a system. The selection and specification of lighting fixtures, lamps and ballasts shall incorporate energy saving techniques such as high efficiency ballasts, lamp technologies, high efficiency fixtures and appropriate fixture selection and placement. A good controls strategy that turns off lighting in unoccupied spaces and reduces it where daylighting is available can contribute significantly to energy conservation. Lighting control elements shall be selected to provide cost effective energy saving systems. The lighting controls shall consist of the appropriate mix of low voltage lighting controls, time of day control, occupancy sensors, daylight harvesting and dimming.

The A-E shall check with local utility companies for technologies that qualify for rebates and apply for them in a timely manner. Some rebates and incentives must be applied for before construction. Also see http://www.dsireusa.org for database of State incentives for renewable energy.

B. Life-Cycle Cost Analyses(LCCA). The LCCA for the Electrical requirements must be completed in conjunction with Electrical analysis that must be performed to meet EPACT 2005. EPACT 2005 requires that the design of all new Federal buildings achieve a level of energy efficiency 30 percent greater than ASHRAE Standard 90.1-2004 if life cycle cost effective. To analyze new Federal buildings, agencies must estimate both the life cycle cost and energy consumption of the planned building as designed and an otherwise identical building meeting the minimum criteria set forth by ASHRAE 90.1 - 2004.

The A-E shall perform this comparison analysis and submit it at the first design submission. This analysis shall show that the planned building is designed 30 percent more energy efficient than an otherwise identical building designed to meet the requirements of ASHRAE 90.1 -2004, if life cycle cost effective.

If the 30 percent savings is not life-cycle effective, the A-E must evaluate the cost-effectiveness of alternative designs at successive decrements below 30 percent in order to identify the most energy-efficient design that is life-cycle cost effective for that building. However, the building must remain compliant with the current version of ASHRAE 90.1.

The A-E shall use the life-cycle cost methodologies described in the latest edition of *Handbook 135, "Life-Cycle Costing Manual for the Federal Energy*

Management Program," published by the National Institute of Standards and Technology (NIST). The life cycle cost analysis must include investment costs, energy costs, non fuel operation and maintenance costs, repair and replacement costs, and salvage values.

C. Energy Savings Methods. The following are energy efficiency design measures that could provide savings.

Installation of larger gauge wires for continuous loads
Installation of power factor correction
Use of energy efficient transformers with an Energy Star Rating
Replacement of oversized and inefficient motors
Installation of variable frequency drives
Installation of on-site renewable energy sources
Implementation of demand response control schemes

D. Additional Energy Efficiency. Several energy saving design elements are listed in the Appendix 5C *Energy Saving Design Appendix*. These are provided to reinforce ASHRAE 90.1 requirements and stress energy saving design elements.

E. Specifying Energy Efficient Products and Equipment

1) To assist in specifying energy efficient products, the Department of Energy (DOE) provides product energy efficiency recommendations and other information at: http://www1.eere.energy.gov/femp/program/equip_procurement.htmlhttp://www1.eere.energy.gov/femp/technologies/procuring_eeproducts.html

2) The A-E shall specify products that are in the upper 25 percent of energy efficiency for all similar products, or products that are at least 10 percent more efficient than the minimum level that meets Federal standards. This requirement shall apply wherever such information is available through either Federal or industry approved testing and rating procedures.

3) The A-E shall, to the greatest extent possible, incorporate energy efficient criteria consistent with ENERGY STAR and other FEMP-designated energy efficiency levels into project specifications developed for new construction and renovation. See http://www.energystar.gov/ .

4) The A-E shall specify environmentally preferable products, such as biobased transformer oil if comparable in price, performance and availability.

F. Sustainable Design. The A-E shall incorporate and apply the sustainable design principles developed for the Federal Government. These principles were developed in compliance with the requirements of the five guiding principles of the High Performance and Sustainable Buildings MOU and Executive Orders 13423 and 13514 and have been incorporated into the internet-based "Whole Building Design Guide" that can be accessed at http: //www.wbdg.org/ . Refer also to the EPA Environmentally Preferable Purchasing website at http://www.epa.gov/epp/.

6.2 ELECTRICAL/ELECTRONIC SECURITY DESIGN

6.2.1 General

Appropriate electrical engineering and electronic security design criteria and standards for a project shall be determined based on project-specific risk assessment done in accordance with the methodology outlined in the Physical Security Criteria for Federal Facilities (See also section 1.4, Security Design). Security design shall be in compliance with Homeland Security Presidential Directive 12 (HSPD-12), Policy for a Common Identification Standard for Federal Employees and Contractors.

6.2.2 Security Considerations for Electrical System Design

A. General. The major security functions of the electrical system are to maintain power to essential building services, especially those required for life safety and evacuation; provide lighting and surveillance to deter criminal activities; and provide emergency communication.

B. Service and Distribution

1) Distributed Emergency Power. Separate normal and emergency electrical power distribution equipment and feeders. Emergency and normal electric panels, conduits, and switchgear shall be installed physically separated by distance and construction to prevent an occurrence on one system affecting the other.

2) Main Fuel Storage. Locate fuel storage for on-site generation away from areas that are high traffic or exposed to the public and personnel such as loading docks, entrances, roadways and parking areas. Access shall be restricted and protected (e.g., fencing, locks on caps and seals).

3) Emergency Fuel Storage. Consider emergency fuel storage for larger systems that require remote fuel sources. The local fuel source shall be mounted near the generator, given the same protection as the generator, and sized to store approximately eight hours of fuel

4) Emergency/Standby Generator. Locate generators away from areas that are high traffic or exposed to the public and personnel such as loading docks, entrances, roadways and parking areas. More secure locations include the roof, protected grade level, and protected interior areas. The generator shall not be located in any areas that are prone to flooding.

   If the generator is installed outdoors at grade, it shall be protected by perimeter walls and locked entrances.

   A battery and/or UPS may be installed to provide emergency power in lieu of an emergency generator to serve a smaller building or leased facility.

5) Utility Service Equipment and Feeders. Locate utility service equipment and feeders away from areas that are high traffic or exposed to the public and personnel such as loading docks, entrances, roadways and parking. Underground service is preferred. Alternatively, above ground equipment, feeders and their support structures shall be protected from damage utilizing construction materials such as bollards, guide rails and fencing.

C. Power and Lighting

1) Site Lighting. Site lighting shall be coordinated with the closed-circuit television (CCTV) system. Although CCTV cameras are available for low-light applications, operations are enhanced with higher uniform lighting levels. Coordinate site lighting foot-candle levels with camera requirements and to provide adequate lighting for security and safety purposes

2) Restrooms. Provide emergency egress lighting for restrooms. Emergency lighting in restrooms may facilitate evacuation or permit limited use during power outages not requiring immediate evacuation.

3) Stairways and Exit Signs. Provide self-contained battery lighting in stairwells and for exit signs as back-up in case of emergency generator lag time or failure. Floor-level evacuation lighting systems shall also be considered since an event may fill corridors with dense smoke. Lighted exit signs shall be LED type.

4) General. Do not over light areas.

6.2.3 Electronic Security

A. General

The Department has determined Lenel e-PACS systems as the physical access system of choice for ARS. All electronic security design shall be designed around this system.

Electronic security shall be considered early in project planning to help ensure that it is a cost-effective integral part of the facility design. The electronic security requirements shall be based on facility-specific risk assessment and integrated with the Physical Security Design, see Section 1.4. The purpose of electronic security is to improve the reliability and effectiveness of life safety systems, security systems, and building functions. When possible, accommodations shall be made for future developments in security systems. Security systems shall be structured cabling systems to the greatest extent possible. All security networks shall have software to protect these systems from outside tampering.

The following are intended to stress those concepts and practices that warrant special attention to enhance public safety. Consult design guides pertinent to your specific project for detailed information about electronic security.

B. Control Centers and Building Management Systems

Centralization of information and head end equipment into a control center can improve the reliability and effectiveness of life safety systems, security systems, and building functions. Operational requirements and standards, especially pre-determined standard operating procedures for various types of incidents, shall be carefully considered.

C. Security for Utility Closets, Mechanical Rooms, and Telephone Closets

Security system wiring/conduit shall not be accessible in utility/telephone closets. As a minimum, a key security system shall be provided to control access. For medium and higher protection levels, access to mechanical, electrical, and telecommunication rooms shall be authorized, programmed, and monitored through pre-identification of maintenance personnel and an electronic access control system with door position monitoring.

D. Elevator Control and Signaling

1) Elevator Recall. An Emergency Operating Procedures might require that elevators not discharge personnel on the first floor (lobby) during some

events. When necessary, a button shall be provided at the Fire Command Center (FCC) or other central control and monitoring station to recall elevators to an alternate floor in the event that the normal evacuation route would involve traveling through a high risk area or that elevators could be safely used to evacuate disabled persons.

2) Elevator Emergency Message. In conjunction with the recall system, a prerecorded message shall be installed in elevator cab speakers, notifying passengers of an emergency and explaining how to proceed.

E. Intrusion Protection System

1) Door Locks. Provide key security system, augmented with electronic access control, where required by the project-specific risk assessment.

2) Intrusion Detection. Basic intrusion detection shall be provided for all entrances into the facility, generally by means of magnetic reed switches. For Medium/Low Level and higher, glass break sensors for windows up to scalable heights should be provided where required by the project-specific risk assessment.

3) Closed Circuit TV (CCTV). CCTV systems may be required depending on the overall result of the project-specific risk assessment. The cameras shall be located to view entrances, monitored exits, vehicular entrances into parking garages, loading docks, and other areas specific to the project. Monitors and camera control equipment shall be located at a central attended location.

All CCTV cameras shall be on real-time with time-lapsed video recorders. For deterrence as well as to aid post incident investigations, key exterior areas (for Medium Level) or most exterior areas (for Higher Level), especially vehicle routes close to the facility, shall be video recorded. The use of digital video systems shall be considered by the designer.

4) Duress Alarms or Assistance Stations. Call buttons shall be provided at key public contact areas and as needed in the offices of managers and directors, in garages, and other areas that are identified as high risk locations by the project-specific risk assessment.

6.3 PRELIMINARY DESIGN CONSIDERATION

6.3.1 Preliminary Data

A. Load Data. Before specific power sources and distribution systems can be considered, realistic preliminary load data, including master planning requirements, shall be compiled. Expected power demand on intermediate substations and on main power supply shall be calculated from connected load calculations and existing loads. Existing loads can be determined from meter readings where available or by load estimation. Determine system loading by load analysis and by combining loads progressively. To combine loads, start at ends of smallest feeders and work back to power sources. Preliminary estimates of lighting loads shall be made by utilizing the lighting power densities located in the current addition of ANSI/ASHRAE/IESNA 90.1 – Energy Standard for Buildings Except Low Rise Residential Buildings. Load calculations shall be performed in accordance with the National Electrical Code.

B. Load Analysis. Analyze characteristics of each load to determine appropriate demand factors. Consider items such as coincidental use, environmental conditions of weather, geographical location, and working hours, as the situation dictates. Base load analysis on the requirements of the National Electrical Code.

6.3.2 Estimation of Loads

A. Lighting Load. Divide facility area into significant components by function. Determine average lighting level and type of light source for each area. Apply appropriate demand factors in accordance with the NEC.

B. General Purpose Receptacles. Account for loads associated with convenience outlets and plug loads. Apply appropriate demand factors in accordance with the NEC.

C. Power Load. Power loads shall include loads other than lighting loads and those served by general purpose receptacles. Apply appropriate demand factors in accordance with the NEC.

D. System Loss. A system loss of six percent, based on calculated maximum demand, shall be added to the building load.

E. Load Growth. Determine the projected future requirements for load growth for anticipated usage and life expectancy with particular attention to possibilities of adding heavy loads in the form of air-conditioning, electric heating, electric data processing, and electronic communication equipment. Use this information to determine the size of service and method of distribution to a facility that is most economical and feasible for serving both present and future loads.

F. Emergency and Standby Loads. Determine emergency and standby power requirements based on four types of loads: emergency loads; legally required standby loads; optional standby; and uninterruptible (no-break) load. The designer shall categorize all emergency and standby loads in accordance with the National Electrical Code and other applicable codes. Critical loads such as bio-containment ventilation systems and contaminated waste disposal systems shall be considered as being a legally required standby load because of the risks caused by losing power to these type loads.

When the four categories of emergency/standby power requirements have been ascertained, determine where local emergency/standby facilities are required, where loads may be grouped for centralized emergency/standby facilities, and what loads are satisfied by the reliability of the general system.

G. Area Loads. Area loads consist of groups of individual facility loads served by a subdivision of the electrical distribution system. The term area applies to the next larger subdivision of an overall distribution system. Demand loads for an area must be known for sizing the distribution wiring and switching.

6.3.3 Standards for Sizing Equipment and Systems

To ensure maximum flexibility for future systems changes, the electrical system shall be sized as follows: panelboards for branch circuits shall be sized with 50 percent spare capacity, panelboards serving lighting only with 25 percent spare capacity, distribution panels with 35 percent spare capacity and main switchgear with 25 percent spare capacity. Capacity is defined by both spare ampacity and circuit breaker spares and spaces. A minimum of 20 percent of the installed overcurrent devices shall be spare devices.

6.3.4 Selection of Power Sources

A. Normal. The normal source shall have sufficient capacity to provide for peak electric power demand during normal operations.

B. Standby. The standby source shall have enough capacity so that it can supply legally required and optional standby loads of the building. The standby source may be utilized as the source for emergency power if designed per the requirements of the NEC.

C. Emergency. Emergency sources, usually one or more engine-driven, automatic-starting emergency generators, shall have sufficient total capacity to provide electric power to serve the emergency loads of the building.

6.3.5 Uninterruptible (No-Break) Power

An uninterruptible (No-Break) power system (UPS) is necessary for certain research activities, critical electronic equipment, or computer rooms with functions that require a continuous power supply. This power system is defined as one that, under all conditions, will provide suitable power to a critical load without interruption. UPS requirements shall be identified during design. The requirements shall include the size and operating time. Other considerations shall include the need for multiple UPS's, parallel UPS's and generator backup for the UPS's.

The no-break system shall be capable of supplying uninterruptable power during voltage fluctuations, sags, surges, and power outages. Successful operation of critical equipment and protection from damage depends on power system reliability. The design of an uninterruptible power supply (UPS) system shall be as simple as possible, using basic applications of power system design practices which have been proven sound and economical for the purpose on a life-cycle basis. The system shall be designed to support the specific project's power availability and reliability requirements.

UPS systems shall be provided with equipment to allow maintenance of equipment without interrupting power to the load being served. Stand-alone UPS's shall be provided with maintenance bypass switches.

6.3.6 Installation of Site Distribution System

Aboveground site distribution shall be avoided. Site distribution shall be underground unless conditions prohibit.

6.3.7 Grounding of Distribution Systems

Distribution system grounding shall be in accordance with the requirements of the NEC. Solid grounding shall be used for automatic clearing of ground faults. Use only on secondary systems or where impedance of transformers is included in a zero-sequence path. This connection shall be avoided for grounding of generators where single-phase line to ground fault current at terminals will exceed three-phase fault current for which they have been braced.

6.4 SERVICES

6.4.1 Service Selection

Selection of service characteristics shall be based on the economic analysis outlined in section 6.1.4 (C)

A. Service Characteristics. Where primary service is selected, three-phase service should be provided, and any voltage class of 34.5 kV or less may be used. The selection of primary service voltage shall be based on the voltage available from the utility company. Secondary service shall be either 208Y/120 volt or

480Y/277 volt, three-phase, 4-wire service.

B. Service Conductors. Service conductors shall be installed underground unless site conditions prohibit. Conductors serving the same load shall be of the same sizes and lengths.

C. Metering. Buildings shall be provided with a revenue primary or secondary metering installation ahead of the main disconnecting device in accordance with the utility company service requirements. Coordinate the requirements with the local service provider. In addition to the revenue meter, each building, over 10,000 gross square feet, and which has high energy demands, shall have an advanced electric meter that has the capability to record interval usage data at least hourly and to communicate information on at least a daily basis to a local computer. Do not connect the meter to a building management system or other controls system. Confirm during design with the Contracting Officer that buildings less than 10,000 gross square feet do not require an advanced meter. Computers connected to advanced meters shall have USDA security software. Meters for other utilities may be connected to the advanced electric meter. Meters will be networked nationally.

D. Service Equipment. Locate equipment at service entrance points. Select the most economical devices to accommodate short-circuit and normal current requirements. Circuit breakers are the preferred service disconnecting device.

6.4.2 Short-circuit, Coordination and Arc-Flash Considerations

Devices shall be able to clear any fault on electrical systems without damage to the electrical equipment or conductors. The designer shall perform a short circuit analysis to determine the fault duty requirements for all system components. The results of the calculations shall be incorporated into the design documents. Short circuit analysis shall be performed in accordance with ANSI/IEEE standards C37 and all UL 489. Calculations shall comply with IEEE 241 and 244 for short circuit currents.

The electrical distribution system shall be designed to allow for selective coordination as required per the National Electrical Code. A protective device coordination study shall be provided. The study shall be performed in accordance with ANSI/IEEE standard 242.

In addition, an arc flash analysis shall be performed and labeling identified for all equipment that will be maintained or inspected while energized. The designer shall assume that all equipment that is inspectable shall require labeling. The analysis shall comply with NFPA 70E and IEEE 1584.

6.4.3 Service Equipment Rooms

Utilities shall be readily accessible, and equipment rooms shall be sized to provide sufficient space for maintenance and for future growth. If electrical equipment is located in an electrical-mechanical equipment room, adequate space for electrical equipment shall be reserved. The space and clearances for electrical equipment shall meet all requirements of the National Electrical Code.

6.4.4 Vaults for Utility Transformers

If space conditions require that the electric utility's transformers be installed on Government property, they may be pad mounted outside the building, or installed in vaults within the building. Vaults shall be constructed as part of the building and shall meet the requirements of the utility company and the applicable codes.

6.4.5 Service Feeders

A. <u>Number</u>. The number and arrangement of incoming feeders shall be based on requirements for maximum uninterrupted service, large motor inrush characteristics, the reliability of the distribution system and the National Electrical Code.

B. <u>Capabilities</u>. Electrical rating of each service feeder shall be based on the sum of distribution feeder requirements, future loads, system demand and diversity factors and the National Electrical Code. Neutrals of secondary services, where required, shall be full-size to carry harmonic currents from electrical discharge lighting, data processing, or similar equipment loads.

6.4.6 Service Feeder Conduits

Conduits for service feeders shall be extended underground from the point of connection with the electric utility's system into the main service entrance equipment.

6.4.7 Service Disconnecting Equipment

A. <u>Primary Disconnecting Equipment</u>. For projects having medium voltage incoming feeders, each feeder shall be provided with a metal-enclosed interrupter switchgear assembly. Each feeder shall supply the substations that are necessary to support the building loads. Interrupter switchgear for a single incoming feeder may be combined with the transformer in a unit substation.

B. <u>Secondary Disconnecting Equipment</u>. Service disconnecting devices shall be low-voltage power circuit breakers or molded case circuit breakers. Power circuit breakers shall be used for secondary services that have ratings in excess of 800 amperes.

C. Ratings. Continuous current ratings of service disconnecting devices shall be calculated on the same basis as the capacities of the feeders they serve. Interrupting capacities of disconnecting devices shall be not less than the fault currents available at the point of connection.

6.4.8 Electric Utility Equipment

Service equipment to be furnished and/or installed by the electric utility shall be shown and identified on drawings and listed in specifications. Each point at which material furnished by the utility terminates and is connected to material that is part of USDA facilities shall be clearly specified and shown on drawings.

6.4.9 Ground Fault Protection

A. Application. Ground fault protection (GFP) shall be applied as required by the NEC. Additional GFP shall be considered on feeder circuits on two or more levels to achieve selectivity for continuity of service.

B. Selection. Economics shall be balanced against the cost of outages and potential cost of research loss or equipment damage to arrive at a practical system. Each system shall be analyzed individually. The following factors shall be considered in selecting GFP.

1) Type of power distribution.

2) Availability required.

3) Neutral circuit complexity.

4) Number of ground return paths.

5) Rating and application of protective devices.

6) Setting of protective devices.

C. Special Considerations. Take particular care in the application of GFP systems where there are a number of ground return paths to the service transformer via building steel and earth ground. GFP equipment can be desensitized by fault current flowing directly to the transformer. Solutions to the desensitizing problem include:

1) Use of zero-sequence ground sensor encircling the phase and neutral

conductors.

2) Use of residually connected individual sensors on each phase and neutral conductor to detect current imbalances.

3) Isolation of equipment grounds from building steel and earth ground (except at service).

4) Source ground current transformers (on neutral).

5) Systems. The two commonly used systems are “residually connected” and “zero-sequence”. The type of system for a project shall be determined by the factors above, and circuit breaker coordination calculations.

6.5 ELECTRICAL EQUIPMENT ROOMS

6.5.1 Planning

Separate electrical rooms shall be provided for medium-voltage and low-voltage switchgear and switchboard assemblies, and for power, distribution, and substation transformers. Rooms shall be located where they will be readily accessible centrally located to minimize cable distribution lengths and costs and free from the danger of flooding. Each room shall be provided with exit doors operated by panic hardware which shall open into space that is accessible at all times. The quantity and location of exit doors shall be in accordance with the requirements of the National Electrical Code.

6.5.2 Clearances

Clearances around electrical equipment shall conform to the requirements of the National Electrical Code. Clearances and working space shall be increased wherever necessary for equipment removal and the use or storage of breaker removal equipment.

6.5.3 Concrete Curbs and Housekeeping Pads

Continuous concrete curbs shall be provided around each liquid-filled transformer or group of transformers. Curb height and area enclosed shall be adequate to contain the liquid from the largest transformer in the group plus 10 percent, in the event of tank rupture.

Housekeeping pads shall be provided for electrical equipment that is floor mounted such as switchgear, switchboards, transformers and motor control centers. Pads shall be a minimum of four inches high.

6.5.4 Equipment Removal

Rooms and adjoining areas shall include clearances, suitable doors, removable windows, panels, or other means to allow electrical equipment to be removed and replaced.

6.5.5 Lighting

Normal room lighting shall be as described in section 6.11. Provide an exit sign over the exit door and emergency lights providing a minimum of one foot-candle illumination. Egress lighting for electrical and mechanical rooms shall be connected to the emergency generator, if available, or shall have 90-minute battery backup.

6.5.6 Climate Control

Climate Control. Ventilation or conditioning shall be provided, as required, to prevent the temperature from exceeding 10^{o}F above outside ambient. Ventilation is the preferred method of temperature control. Where possible, make-up air for ventilation shall be obtained directly from the outside. Provide fire dampers as appropriate to maintain fire ratings. Coordinate requirements with mechanical design.

6.6 PRIMARY DISTRIBUTION SYSTEM

6.6.1 General Description

The primary distribution system may consist of Utility or Government-owned incoming feeder conduit banks, medium-voltage metal-clad switchgear, distribution feeders and raceways, substations, auxiliary switchgear, and secondary unit substations. The designer shall coordinate with the utility company and the project requirements to determine the system configuration and division of responsibilities for the primary distribution system. The designer shall select the appropriate distribution system based on required reliability, economic considerations, and system requirements.

6.6.2 Distribution Feeders

The capacities of medium-voltage distribution feeders shall be determined on the same basis as primary service feeders. A separate feeder shall be provided for each transformer in a primary substation. Feeders supplying secondary substations may serve more than one transformer.

6.6.3 Feeder Raceways

A. Electrical Equipment Spaces. In electrical equipment rooms, electrical closets, and similar spaces, medium-voltage distribution feeders shall be installed in galvanized rigid steel conduits. Cable trays may be used to support medium-voltage distribution feeders in electrical equipment rooms. Exposed power cables shall be fireproofed throughout or be an appropriate, listed cable assembly. Top connections shall be provided to the transformers and switchgear assemblies.

B. Risers. Conduits for medium-voltage feeder risers shall be galvanized rigid steel. Where they are not in electrical closets, electrical equipment rooms, or transformer rooms, each conduit or group of conduits shall be protected as required by the NEC.

C. Structural Coordination. Design of interior and exterior medium-voltage distribution systems shall be coordinated with the structural design features to ensure that structural drawings show all details of supports, reinforcements, dowels, etc. required for a satisfactory installation.

D. Primary Conduits. Conduits containing medium voltage cables, over 600 volts, shall be provided with labeling to indicate that these are high voltage feeders.

6.6.4 Primary Substations

A. High Voltage. Where primary service voltage exceeds 34.5 kV, a primary substation shall be provided by the electric utility to reduce the voltage. The substation shall be of joint use and may include the Government-owned, medium-voltage metal-clad switchgear required for the site distribution system. The firm capacity of the substation shall be determined by the electric company.

B. Medium-Voltage. Medium voltage substations shall be provided where required to supply power for large medium-voltage motors, such as those driving air-conditioning compressors and pumps. Outgoing distribution voltage shall be 4.16 kV. The firm capacity of each substation shall be equal to the sum of the kVA ratings of the medium-voltage motors served at a demand factor of 100 percent. Total transformer capacity provided shall equal, or exceed, the calculated firm substation capacity, and shall allow for known expected growth but not include reserve capacity. Transformers shall be high efficiency.

6.6.5 Batteries

Those projects requiring high-voltage or medium-voltage circuit breakers shall be provided with a 125-volt DC storage battery bank. Each bank shall be monitored so that an alarm will sound when the voltage falls below that required to operate the trip coil. Power shall be provided to circuit breakers, as described below, for operation of breakers.

Battery banks shall be of the nickel-cadmium, lead-acid, or lead-calcium type. Battery banks shall have capacity to carry continuous loads (relays, indicating lamps, etc.) for eight hours and perform either the tripping or the closing operation described below with the charger de-energized and a final voltage of not less than 105 volts. Simultaneous tripping of breakers in the primary system shall be required. Closing operation shall require closing the largest single breaker, if the installation contains fewer than four circuit breakers, and two circuit breakers, if the installation contains more than two circuit breakers. Breaker closing current shall include spring release coil current and starting current of the spring charging motor.

Ratings for batteries shall be determined by assuming that duration of the tripping or closing load is one minute, and adding the equivalent of the continuous load for eight hours. A safety factor of 1.80 shall be applied.

Each battery bank shall be provided with static charging equipment fed from a panelboard connected to the standby power source when available. Battery bank and charging equipment shall be installed in, or near, the electrical room containing the equipment that it serves. Batteries, racks, charging equipment, auxiliaries, etc. shall be shown on drawings. Adequate space for maintenance shall be provided.

6.6.6 Unit Substations

Primary unit substations shall consist of a primary terminal chamber, a fused three-pole, three position disconnecting and grounding switch, a power transformer, and an outgoing feeder section close-coupled as an integrated unit. Primary terminal and switch chambers shall be welded to transformer enclosures or tank. Transformers shall be a dry type or a high-fire point, liquid insulated type. Outgoing feeder section shall be contained in a suitable steel housing welded to the transformer enclosure or tank. Space shall be provided within the housing for the fused potential transformer required for metering and control. Primary terminal chambers and the outgoing feeder section housing shall be arranged for top connection of the feeder conduits.

Secondary unit substations shall consist of a medium-voltage fused load-interrupter switch, a transformer, a low-voltage section, and necessary transition sections close-coupled as an integrated unit. Primary service disconnecting and metering equipment shall be included where required. Transformers shall be either high-fire point, liquid-insulated, or ventilated, dry type. A ventilated, dry transformer shall be used only when the rating does not exceed 500 kVA, where dust and moisture conditions are favorable, and where the sound level will not affect the functions in the areas surrounding the transformer.

Where a project requires a single unit substation served by a single medium-voltage feeder, the service disconnecting and metering equipment shall be integrated with the primary switchgear. Where two primary feeders serve two unit substations in the same location, they shall be arranged for primary selective operation, but shall not be double-ended unless necessary to meet the project requirements.

6.7 SECONDARY DISTRIBUTION SYSTEM

6.7.1 General

Use only copper conductors. Aluminum conductors are not acceptable. Insulation shall be rated 90 ^{o}C or higher in areas subject to abnormal heat, such as a boiler room.

A. Where 480Y/277-volt, three-phase, 4-wire service is provided for fluorescent lighting and power, dry type transformers shall be installed to provide 208Y/120-volt current for other lighting, receptacles, small motors, etc.

B. Motors smaller than 1/2 horsepower may be connected to 120-volt single-phase circuits. One-half horsepower and larger motors shall be connected to three-phase circuits, except where single-phase motors are furnished as standard factory assembled parts of machines, such as kitchen equipment and window-mount air-conditioners.

C. All feeders and branch circuits shall contain an insulated equipment grounding conductor sized in accordance with the NEC.

6.7.2 Low-Voltage Switchgear Assemblies

Low-voltage switchgear assembly may be provided for each building and secondary substation that requires secondary service rated 2000 amperes and above. Switchgear shall be used when the project requires the reliability and durability of switchgear. The designer shall perform an economic analysis to determine if switchgear is appropriate for projects that require secondary service 2000 amperes and above. Secondary service disconnecting devices and metering equipment shall be included in main switchgear assemblies. Each switchgear assembly shall include a circuit breaker for each outgoing feeder. Devices shall be the draw-out type.

Each low-voltage switchgear assembly equipped with circuit breakers shall be provided with one spare circuit breaker and two spaces (completely equipped compartments without breakers) for accommodation of future loads. Ratings of spare breakers and future breakers shall be indicated on drawings duplicating ratings of active breakers. Where known loads are anticipated in the near future, spare units of approximate ratings shall be provided. When possible, switchgear assemblies shall be arranged so that additional vertical circuit breaker sections may be installed.

Switchboard assemblies shall be provided for each building and secondary substation that requires secondary service rated below 2000 amperes and where the project does not require switchgear assemblies. Switchboards shall be enclosed, dead-front construction. Secondary service disconnecting devices and metering equipment, where required shall be included in main switchboard assemblies. Each switchboard assembly shall include a circuit breaker for each outgoing feeder. Feeder circuit breakers shall be group mounted, and main circuit breaker shall be individually mounted.

Each switchboard assembly shall be provided with 20 percent spare circuit breakers sized to proportionally match the in-use circuit breakers. Indicate the ratings of the spare circuit breakers on the drawings. Where possible, switchboard assemblies shall be arranged so that additional distribution sections may be installed.

6.7.3 Over Current Protection

Overcurrent protective devices shall provide continuity of service, and short-circuit ratings and trip settings shall be based on values resulting from system coordination. Selection of over current protective devices for secondary distribution equipment shall be made on the basis of load current, available fault current, and selective operation.

Low-voltage power circuit breakers with draw-out mountings in metal-enclosed switchgear shall be used when trip rating is 2000 amperes and above. Where interrupting capacity of the breaker alone is inadequate, or where cost of a breaker of adequate interrupting capacity is not justified by service requirements, breakers and high-interrupting-capacity current-limiting fuses may be used in combination.

Molded-case circuit breakers with fixed mountings may be used in switchboards when trip ratings are not more than 1600 amperes and their interrupting capacities, with or without current-limiting devices, are adequate. Molded-case circuit breakers shall not be connected to buses of a metal enclosed switchgear assembly consisting mainly of low-voltage power circuit breakers. When molded-case breakers are used for a switchgear assembly, they shall be segregated on a separate switchboard section or panelboard section having its own buses fed through a low-voltage feeder breaker. Molded case circuit breakers rated above 225 amps shall be provided with adjustable trip units.

Place switches where necessary for isolation purposes. To determine switch ratings, follow the procedure outlined for circuit breakers. Switches shall be derated to 80 percent of maximum capacities.

Locate fuses where required to protect low voltage signaling and control circuits against overloads or short circuits. Determine rating of fuses, based on voltage, current carrying capacity, and interrupting capacity. Take into consideration all forms of inrush current.

6.7.4 Motor Control Centers

Motor control centers (MCC) with NEMA Class I Type B wiring and combination motor starter/ circuit breaker disconnects and variable frequency drives shall be provided, in lieu of separately mounted motor starters, where several motors are located in close proximity and the use of an MCC is economically feasible. Unless the MCC is located in sight of, and within 25 feet of a motor it controls, a disconnect switch shall be provided at that motor.

The mechanical engineer shall be responsible for specifying proper types and sizes of motors and type of controller and for indicating the motor locations on drawings. This information must be given to the electrical engineer who shall be responsible for providing suitable feeder sizes, controllers, switchgear and transformer capacities, etc. to service motors, and for selecting line voltages and other current characteristics in cooperation with the mechanical engineer.

6.7.5 Panelboards

Panelboards shall be equipped with molded case, bolt-on circuit breakers. Plug-in breakers are not acceptable. Panelboards shall use copper bus and shall be rated to withstand the available fault current.

A main distribution panelboard shall be provided for a system that requires secondary service rated 200 to 600 amperes. The main panelboard shall have an overcurrent protective device for each lighting and appliance panelboard. A main distribution panelboard will not be required in a building having only two or three lighting and appliance panelboards and a service disconnecting device with a rating of 200 amperes or less.

Branch circuits' overcurrent protective devices in a distribution panelboard shall have a trip rating not lower than the calculated load of the feeder served but not exceeding 800 amperes. Each distribution panelboard shall be provided with 20 percent spare overcurrent protective devices with appropriate ratings and space for anticipated load growth.

Lighting and appliance branch circuit panelboards shall be arranged so that each panelboard shall contain 30 or 42 branch circuits, including spares and spaces. The number of spare overcurrent devices and spaces for future overcurrent devices shall not be less than 20 percent of the active circuits. Overcurrent devices shall have 20-

ampere ratings, except where higher ratings are required. Overcurrent devices for No. 14 AWG conductors in existing construction shall have a 15-ampere rating. Devices for motor circuits shall have the highest ratings permitted by the NEC for the associated motors and starters.

Emergency panelboards shall be provided to supply, through independent circuits, exit lights, stairway lights, emergency lights, building controls, fire pumps, fire alarm and other fire protective systems. Standby power panelboards shall be provided to serve legally required, optional standby and essential equipment. Essential equipment shall include equipment required to support critical research functions. Emergency and standby power panelboards shall be fed from one of the sources described in section 6.10.

6.7.6 Electrical Closets

Except where indicated below, electrical closets shall enclose panelboards, feeder conduits, busways, and dry type transformers.

A. Spacing. The preferred spacing between electrical closets is so that 277-volt circuits will not exceed 200 feet in length and so that 120-volt circuits will not exceed 100 feet in length. If closets are spaced greater than these distances, voltage drop issues shall be addressed using other methods such as increased conductor sizing and installation of additional branch circuit panels. The latter spacing is preferred where both 277-volt and 120-volt circuits are fed from the same closet. If closets are spaced greater than these distances, voltage drop issues shall be addressed using other methods such as increased conductor sizing and installation of additional branch circuit panels. The above spacing shall be modified to suit under floor raceway requirements and to suit telephone closet requirements, as necessary, where electrical and telephone closets adjoin.

B. Location. Electrical closet locations shall be determined early in the design of a building and shown on design development submission drawings. Closets shall be arranged vertically, one above the other, and shall be accessible from corridors or public spaces. In no case shall access be through another wire closet or from a toilet, toilet vestibule, stairway, or stairway landing. Closets shall not be located where entry of conduits or under floor raceways is blocked by obstructions such as columns, shear walls, toilets, stairways, flues, janitor gear rooms, service closets, mechanical equipment spaces, vaults, elevator hoistways, and pipe and duct shafts. Where electrical and telephone closets adjoin, the telephone closet shall have the position more accessible to the under floor raceway header capacity. Adjacent electrical and telephone closets shall be provided with a 2-inch sleeve for interconnections. Maintain separation distances between high voltage and low voltage equipment and conductors to avoid EMI. See the ARS Telecommunication Distribution Design Guide.

C. Size. Closets shall be large enough to contain equipment and terminations in initial installation and to allow anticipated future expansion.

D. Arrangement. Equipment in each electrical closet shall be arranged for maximum accessibility. Dry type transformers, rated 75 kVA or smaller shall preferably be mounted on the wall or hung from the ceiling to afford maximum working floor space. Transformers shall be provided with isolation supports to minimize sound transmission. Contract drawings shall include detail drawings showing the arrangement of equipment, busways, risers, sleeves, transformers, panelboards, tap boxes, junction boxes, cable anchor boxes, wire troughs, and other electrical items to be installed in closets. Where busways pass through closet floors, concrete curbs three inches high shall be provided around openings. Vertical joints between curbs and walls shall be caulked.

E. Future Additions. When it is known that a building is designed for future expansion, sleeves shall be provided in electrical closets for all feeders, communication system conduits, etc. required to serve the future load.

F. Climate Control. Ventilation or conditioning shall be provided, as required, to prevent the temperature from exceeding 10°F above outside ambient or 10ºF below maximum operating temperature of equipment whichever is lower. Ventilation is the preferred method of temperature control. Where possible, make-up air for ventilation shall be obtained directly from the outside. Provide fire dampers as appropriate to maintain fire rating. Coordinate requirements with mechanical design.

G. Lighting. See section 6.11 - Illumination

H. Receptacles. Duplex receptacles shall be provided in each electrical space. Receptacles shall be installed in the wall 12 inches above the floor, maximum 12 feet on centers and each connected to a separate 120-volt circuit in a branch circuit panelboard.

I. Fireproofing. Where sprayed-on fireproofing is used on the underside of cellular steel floors over electrical closets, suspended ceilings or other means shall be used to cover fireproofing.

J. Closets Not Required. Electrical closets may not be required in certain buildings. Panelboards may be mounted on walls and columns. Wall-mounted panelboards shall be recessed. Provide minimum (2) two inch conduits from each recessed panel to above accessible ceilings to allow for the installation of future circuits. Dry type transformers, if required, may be installed above accessible ceiling spaces

6.8 UNDERGROUND DISTRIBUTION SYSTEM

6.8.1 Direct Burial

Install direct burial cables in areas that are rarely disturbed. Restrict direct burial to branch circuits and to street lighting systems. Provide detectable warning tape in the branch above direct buried cable and warning markers at each change of direction of the cable. For protection against mechanical injury and where required to meet utility requirements, high-voltage direct burial cables shall be provided with a protective covering of steel armor. Where corrosive soils are encountered, armored cables shall be provided with a plastic or synthetic rubber jacket.

6.8.2 Duct Lines

Select duct routes to balance maximum flexibility with minimum cost and interference with foundations for future buildings and other structures. When it is necessary to combine communication lines with power distribution lines, provide two isolated systems in separate manhole compartments. Where possible, run communications and power ducts in same concrete envelopes.

Electrical ducts shall be kept clear of other underground utilities, especially high-temperature water or steam pipes. When sizing conduits, consider the following: for general power distribution, standard design requires ducts of four or five inches. For communication duct banks, a minimum size of four inches may be acceptable. Perform cable pulling calculations and size ducts based on the results of these calculations.

Top of duct banks shall be kept to a minimum of 18 inches below grade. Under roadways and runways, a minimum coverage of 24 inches is required, and under railway tracks, 36 inches. Increase the depth of the top of the duct bank to be below frost line. Provide duct bank reinforcing where warranted by soil conditions, loading, or other structural concerns. Drain ducts to manholes with a constant slope of three inches or more per hundred feet. Where two manholes are at different elevations, a single slope to the lowest manhole is acceptable. When grades are flat or crest between manholes, the duct bank shall slope from the middle of flat sections or the peak of the grade in both directions to two manholes.

New underground systems shall include a sufficient number of spare ducts for planned future expansion.

6.8.3 Manholes and Handholes

Factors bearing on the choice of manholes and handholes include number, direction, and location of duct runs; cable racking arrangement; method of drainage; adequacy of work space (especially if equipment is to be installed in the manhole); and size of the opening required to install and remove equipment.

Place manholes or handholes as required for connection or splices, at street intersections, and where necessary to avoid conflict with other utilities. Manhole separation shall not exceed 600 feet on straight pulls and 300 feet on pulls with changes of direction runs. Decrease spacing where necessary to prevent installation damage. Prepare cable pulling calculations during design of duct banks to verify duct sizes, jam ratios and pull locations.

Two-section manholes shall be used where power and communication lines follow the same route.

Where an extension is anticipated, provide a set of stubs so that the manhole wall will not be disturbed when an extension is made.

6.8.4 Underground Cables

Designer shall specify the cable that provides the required physical properties at the most economical cost. The preferred insulations for underground installation are XHHW for low voltage cables and EPR for medium voltage cables.

6.8.5 Underground Transformers

Use vaults to house transformers and associated equipment for underground distribution systems that cannot be installed as pad-mounted transformers.

Vault design shall include the following provisions:

A. Adequate ventilation shall be provided to prevent a transformer temperature in excess of the values prescribed in ANSI C57.12.00. This limitation requires that most electric heat losses must be removed by ventilation; only a minor part can be dissipated by vault walls. The NEC recommends three square inches of clear grating area per kilovolt-ampere of transformer capacity. In localities with above average temperatures, tropical or subtropical, this area should be increased or supplemented by forced ventilation, dependent upon temperature extremes.

B. Adequate access shall be provided for repairs, maintenance, installation, and removal of equipment.

C. Isolation shall be provided to prevent communication of fires or explosions to adjacent vaults.

D. Vaults shall be provided with drainage. When normal drainage is not possible, provide a sump pit to permit the use of a portable pump.

6.8.6 Safety Considerations

Electrical equipment and hardware installed in vaults and manholes shall be effectively grounded to rods provided for this purpose. Metallic sheaths and exterior shields of cables shall be grounded at each manhole. Manholes shall be sized to allow sufficient work space based on the equipment and cabling that will be installed.

6.9 BRANCH CIRCUIT WORK

6.9.1 Wiring and Capacities

Branch circuits shall be provided with insulated copper conductors (minimum No. 12 AWG) in metallic raceways or in cable assemblies. All branch circuits shall have separate green insulated grounding conductors installed in a raceway along with supply and/or neutral conductors. Provide a separate neutral for each circuit requiring a neutral. Shared neutrals are not acceptable.

A. Metallic cable (type MC) shall also have a separate insulated or bare copper grounding conductor installed in the cable with the supply and/or neutral conductors.

B. Wiring shall be run concealed in finished spaces unless precluded by wall construction or other considerations such as bio-containment construction.

C. No more than eight duplex receptacles shall be connected to an individual 20-ampere circuit. Provide dedicated circuits for copiers, printers, autoclaves, freezers, refrigerators and other loads requiring a separate circuit.

D. Individual lighting and appliance branch circuit loads shall not exceed 1600 watts for 120-volt circuits and 3200 watts for 277-volt circuits.

E. Motor branch circuits and special receptacle circuits shall be sized in accordance with the NEC requirements.

F. Flat conductor cable is unacceptable in the research laboratory and associated buildings and facilities. This cable is allowable and more suitable in the administrative and office areas.

G. Harmonic currents on the neutral conductors shall be addressed during design for circuits serving loads that generate high harmonic currents. Perform a harmonic analysis and design suitable mitigation techniques to address all harmonic current issues. Do not reduce the neutral wire gauge, as allowed by the NEC, for branch and feeder circuits.

H. The effect of variable frequency drives on motor bearings shall be addressed during design. Designs shall incorporate mitigation techniques to prevent motor and motor bearing failure caused by the effects of variable frequency drives.

6.9.2 Switching

For control of lighting, refer to section 6.11

6.9.3 Receptacles

Duplex receptacles shall be 20-ampere, 125-volt grounding type unless otherwise noted. Furnish grounding conductors for metallic boxes. Connect grounding conductors to receptacle ground terminal, branch circuit grounding conductors, and box grounding conductors with a metallic crimp. Wire nuts are not acceptable. Receptacle circuits shall be entirely separate from lighting circuits. Concerning receptacle requirements for the physically disabled, see ADA requirements.

In addition to receptacles required for spaces and equipment described in paragraph 6.9.1, receptacles shall be provided in the locations for purposes indicated below.

Provide 20-ampere, 125-volt grounded type weatherproof duplex receptacles within 25 feet of roof top or outdoor air-conditioning or heating equipment.

Provide ground fault circuit interrupter (GFCI) protection for each of the following receptacles in addition to those receptacles required to have GFCI protection for locations listed in the NEC, including receptacles, 125VAC, 20-, and 30-ampere, within a 3-foot radius of water supply, such as a sink. Ground fault reset shall be located at the receptacle and not at the panelboard.

6.9.4 Emergency Lighting

Exit lights shall be provided as required by the NFPA, including requirements detailed in the NEC, Life Safety Code, and local codes, and shall be supplied from emergency panelboard or supplied with integral batteries where emergency power is not available.

Emergency lights shall be provided for egress paths, including exit routes, exit stairways, exit passageways, large open areas such as assembly areas, cafeterias, and open-plan office spaces where the exit is normally through the major portion of these areas.

Mechanical/electrical equipment rooms and vaults, emergency generator rooms, elevator machine rooms and pits, guard rooms, etc. shall also be provided with emergency lights with a minimum of one foot candle illumination.

Emergency lights shall be supplied from emergency panelboards without switch control. Emergency lighting shall be rapid starting; high efficiency fluorescent lamps or tubes shall light from cold start within five seconds. If an emergency power source is not available, emergency lighting shall be provided by battery units, emergency battery ballasts, or central inverters.

6.10 EMERGENCY AND STANDBY POWER

6.10.1 General

Keep requirements for emergency and standby power to the minimum identified within the project's Program of Requirements. Facility location will provide detailed data describing their minimum emergency and standby power needs, heat generating equipment, and equipment requiring uninterruptible and conditioned power.

6.10.2 Applications

Emergency, legally required standby power, and optional standby power loads shall be categorized per the NEC.

6.10.3 Emergency and Standby Power Sources

Building size, loads and life-cycle costs shall be used to determine if a battery or generator system, or a combination of them, is the most economical power source. Batteries and static inverters shall be considered when loads do not exceed 20 kVA, provided elevators or other motor loads are not served by them. A single generator shall be provided for each building; where feasible, use a single generating plant for multiple buildings in a complex.

Connection to two separate primary sources via appropriate transformers or utility network system may be used in lieu of a generator if acceptable to the Authorities having jurisdiction and the Contracting Officer.

6.10.4 Loads

A. If elevators require emergency power, loads shall depend on the number of elevators as follows:

   1) Six elevators or less, the load of one elevator. (Note: Provide feeder

connections and other facilities to operate one elevator continuously, while remaining elevators are operated one at a time.)

2) More than six elevators, the load of two elevators. (Note: Provide connections to operate one elevator at a time.)

B. Equipment loads shall consist of power required for equipment that must operate continuously and that of the general lighting in the equipment areas not included in emergency system loads.

C. Emergency system loads shall consist of lights and equipment served by emergency panelboards.

1) Fire alarm system, fire pumps, security alarm systems, etc.

2) Stairway lighting.

3) Corridor lighting.

4) Exit and emergency lighting in essential machine rooms and guard offices, etc.

D. Optional standby loads shall consist of the following:

1) Receptacles in telephone equipment closets.

2) Equipment, such as communication systems and automatic data processing systems, where an interruption might cause a hazard or other serious problems.

3) Pumps to prevent flooding that might damage buildings or contents, and other essential pumps.

4) Essential heating equipment in cold climates.

5) Mechanical HVAC control systems.

6) Generator auxiliary equipment, including:

7) Damper motors, supply and exhaust fans, radiator fans (remotely mounted radiator only), and generator room ventilation and controls.

8) Fuel oil transfer pumps.

9) Battery chargers.

10) Generator alarms.

11) Additional motors not driven by the generator engine.

6.10.5 Uninterruptible Power Requirements

When certain equipment cannot tolerate a short break or minor variation (voltage, frequency, or wave form) in the power supply, special equipment necessary for uninterruptible power shall be provided. Where a generator is provided, it shall supply power to the uninterruptible power system.

6.10.6 Generators

Generator capacity shall be adequate to serve the connected loads. Inrush current of the largest group of motors, automatically started simultaneously, shall be considered. The initial voltage dip shall not exceed 20 percent. If there is a fire pump connected to the generator, the voltage dip shall be limited to the NFPA requirements for voltage dip for fire pumps.

Where a generator must be automatically started and loaded, the lubrication oil supply for the prime mover shall be kept to at least 75 percent of its optimum operating temperature, and a separate electric pump shall maintain a positive continuous flow of lubricant to all bearings.

Diesel engines shall be used to drive generators. Where natural gas is available and where used for emergency power generation is acceptable to the authorities having jurisdiction, gas engines may be used. Fuel cells or micro turbines may be acceptable if cost effective. Provide a feasibility and life cycle cost analysis for systems other than diesel engine driven generators that are proposed.

Where a generator is installed indoors, the generator shall be installed in a separate room with at least one exterior wall. The room shall be provided with a fire-resistive enclosure. Noise and vibration and their effect on surrounding rooms shall be considered in selecting the location. Walls of generator rooms shall be constructed of materials to prevent transmission of objectionable levels of sound and vibration. Room shall be provided with adequate ventilation and a combustion air supply. A motor-operated louver damper shall be provided on engine radiator air discharge. Air shall be so discharged that it will not re-enter the room. The room shall be provided with adequate access for servicing or replacing equipment. Means shall be provided to heat equipment room to 60 ^{o}F during idle periods, unless the generator is equipped with crankcase heaters for cold starting. Lifting eyes or chain hoist monorails shall be provided over separate components exceeding 50 pounds in weight. Headroom shall be provided to operate lifting devices.

Engine water cooling system shall be either remote or engine-mounted, so arranged that pressure on the head of the engine block will not exceed six psig. Where remote-mounted radiators create static pressure in excess of six psig, provide a separate pump, receiver tank and piping to the radiator to prevent rupturing each gasket by excessive pressure.

The generator fuel storage tank shall have fuel capacity for a minimum of forty eight hours of continuous generator operation at a full load. However, larger capacity shall be justified, depending on the record of electric outages and fuel availability.

Engine exhaust pipe shall be extended to the exterior of the building as directly as possible, to prevent exhaust discharge from polluting the building. Prevent exhaust reentry. The exhaust system shall be designed in such a manner that the back pressure to the engine will, in no case, exceed 20 inches water gauge. Engine exhaust mufflers (silencers) shall be provided for each engine-generator set to ensure acceptable noise levels with the minimum muffler grade being residential grade.

6.10.7 CHP Energy Systems

The possibility of having a combined heat and power (CHP) energy system, where an engine generator or group of engine generators either supplies all or part of the electric power, heating, hot water, and air-conditioning needs for a building, shall be considered. In conjunction with the mechanical engineer, evaluate the feasibility of such a system to meet prescribed energy consumption goals for new buildings. In addition, evaluate the use of demand response techniques to limit the facility's peak demand, energy costs and installed electrical distribution system costs.

6.11 ILLUMINATION

6.11.1 Scope

This section outlines the requirements for illumination of buildings, but is not intended to cover all conditions. Where there are unusual problems or conditions, special studies shall be necessary to establish what will be appropriate and economical to install, maintain, and operate.

6.11.2 Lighting Systems

Lighting systems shall be designed with high efficiency fluorescent lighting fixtures and lighting equipment utilizing energy saving rapid-start lamps. Consider full spectrum lamps. All lamps and light fixtures shall have an efficiency in lumens per Watt that meets the requirements of EISA section 321(a)(3)(A) and are not being discontinued by Statute or DOE rulemaking. Ballasts shall be electronic, energy efficient, and shall meet UL Class P requirements, equipped with built-in automatic reset thermal protectors. Ballasts shall have an A sound rating. Do not use incandescent lamps unless necessary for operational purposes. Lighting power density shall meet the requirements of the current edition of ASHRAE 90.1. Energy efficient lighting systems such as LED shall be considered if economically feasible and advantageous to meet energy usage requirements.

Lighting systems shall be coordinated with the architecture/interior design of the building with regards to the aesthetic and decorative effects within the limits of visual acuity, visual comfort, economics and energy conservation.

Lighting calculations shall adhere to the established procedures of the IES Lighting Handbook and IES recommended practices. Utilize task lighting techniques to allow lower average area lighting levels. Do not over-light spaces. For large buildings, a comprehensive lighting study shall be required from an economic viewpoint to aid the selection. When studying alternatives, consider initial investment, life span of the installation, energy expense, cost of replacing lamps, and cleaning cost.

The following methods of energy conservation shall be considered: occupancy sensors, switching flexibility; time or photoelectric control; use of high efficiency lighting fixtures and systems; daylight harvesting; fixture dimming; task lighting; provision of ceiling construction and wiring methods which easily accommodate lighting fixture relocation; use of building automation systems for controlling lighting fixtures.

6.11.3 Lighting Fixtures

Particular effort shall be made to reduce the number of lighting fixtures types in a facility, building, or project, so that the number of spare parts and replacement lamps required for maintenance shall be kept to an absolute minimum.

6.11.4 Maintenance

Ease of servicing lighting fixtures must be considered in the design process. For lighting fixtures installed in areas where it is difficult and hazardous to re-lamp fixtures when using ladders, appropriate consideration shall be given to mounting heights of fixtures and access to safely perform re-lamping activities.

6.11.5 Switches

Local light switch control shall be provided for individual rooms with fixed partitions. Three and four-lamp fixtures may be double switched to provide two levels of illumination. Office lighting shall be controlled by switches mounted on permanent partitions and columns (off center line). Switches in re-locatable partitions shall be avoided wherever possible. Local switching shall be provided to insure maximum flexibility. Corridor lighting shall be controlled by switch located near the elevator core or by a remote control system.

6.11.6 Exterior Lighting

Parking areas, exterior traffic lanes, and pathways to buildings shall be illuminated with fixtures designed for use with energy efficient lamps providing illumination levels recommended in Illuminating Engineering Society of North America standards. Lighting fixtures shall be full cut-off type to limit the potential for light pollution. Consider photovoltaic power and the use of low pressure sodium lamps in marine applications.

6.12 SPECIAL EQUIPMENT

6.12.1 Elevators

A. Feeders. Each isolated elevator and each group of two elevators shall be provided with an individual feeder. Each group of three or more elevators shall be provided with not less than two feeders. Where feasible, feeders serving a group of four or more elevators should originate in different substations.

B. Switchboards. Switchboard assembly, generally a NEMA Type I, shall be provided where there are two feeders as described above. The bus shall be divided so that each feeder connects to a separate section serving half of the load. For each elevator served, the switchboard assembly shall be provided with a circuit breaker. In addition, provide an automatic transfer switch and feed to panelboard for signal power, etc., as described below. A transformer shall also be provided, where necessary, to furnish the required voltage.

C. Circuit Breakers. Each elevator feeder shall terminate in a separately enclosed wall-mounted circuit breaker.

D. Signal Power. A panelboard fed by the transfer switch (described above under switchboards) shall be provided for elevators. The panelboard shall contain circuit breakers to supply power for either signals or group supervisory control car light. Where freight elevators are equipped with freight type power-operated hoist way doors, a 3-pole circuit breaker of suitable size shall be provided to supply power for the doors.

E. Wiring. Wiring shall be provided to the terminals of controls furnished by the elevator contractor. Where controls are not in the same rooms as switchboard assemblies with circuit breakers required above, additional disconnect switches shall be provided per NEC requirements.

F. Receptacles. Not less than one duplex receptacle shall be provided on each elevator machine room wall. A duplex weatherproof receptacle and light fixture shall also be provided in each individual elevator pit and in each section of a multiple-hoist way pit.

G. Standby Power for Elevators. When power is provided from a standby engine-generator set, automatic transfer switches should be provided, and normal feeders shall be utilized to distribute emergency power. Where use of normal feeders is determined to be impractical for this purpose, emergency feeders and necessary automatic transfer switches shall be provided. Auxiliary control contacts shall be provided on each automatic transfer switch, and conductors in conduit extending to controls in the elevator machine room. Auxiliary contact circuits, in conjunction with elevator controls, shall function to prevent any elevator from starting automatically as long as emergency power is being applied to elevators. A selector switch shall be provided as part of the elevator installation which will permit authorized personnel to select one or a limited number of elevators at a time for operation on emergency power to:

1) Release passengers who may be trapped in a stalled elevator.

2) Provide limited emergency power to authorized personnel during the power interruption.

3) Elevator Fire Capture System. This system shall meet ANSI A17.1 code.

6.12.2 Hazardous Locations

Equipment, material, and devices installed in hazardous locations and details of their installation shall conform to NEC requirements and other applicable recommendations of NFPA. Hazardous locations include paint shops, and locations exposed to flammable liquids and gases and combustible dust and fibers, as defined by the NEC Article 500. Requirements of local agencies having jurisdiction over the completed project shall also be met.

6.12.3 Lightning Protection

All metal flagpoles and metal stacks either attached to buildings or free standing shall be grounded.

All facilities having a tolerable lightning frequency greater than the expected lightning frequency, in accordance with NFPA 780, shall have complete lightning protection systems included in their design. A complete lightning protection system shall be a system of air terminals, conductors, ground terminals, interconnecting conductors, arresters, and other connectors or fittings required to complete the system. The lightning protection system shall be required to be provided with a UL Inspection Certificate.

Facilities with a tolerable lightning frequency less than or equal to the expected lightning frequency shall be evaluated by the design A-E in conjunction with the project EPM with respect to safety, research programs, and economic factors to determine the extent of lightning protection required.

6.13 TELECOMMUNICATIONS AND SIGNALING SYSTEMS

6.13.1 Telephone and Data Systems

Telecommunications distribution facilities design requirements are defined in FD PGM-06-001 *Telecommunications Infrastructure Guidelines* and the ARS *Telecommunications Distribution Design Guide* found at the Facilities Division SharePoint site. For additional references, see Paragraph 1.2.3.E *Telecommunication Requirements.*

6.13.2 Fire Alarm Systems

A. A fire alarm and detection system or addition to existing systems shall be included for all projects. The fire alarm system shall comply with the latest edition of NFPA 72. The system shall utilize an addressable microprocessor based type system with manual and automatic alarm initiation. Signal transmission shall be a multiplex format and be dedicated to the fire alarm service only. All fire alarm equipment shall be UL listed for its intended purpose.

B. Location of Control Console. The control console shall be installed in the engineer's office or other approved location, and a remote graphic annunciator shall be installed in the lobby within view of, and easily accessible to, outside fire fighting personnel. In buildings where 24-hour guard service is provided, the control console shall be located in the guard's office with remote indicator in the engineer's office or other approved location.

C. Audible fire alarm indication shall be via horns or electronic speakers. Visual alarm indication shall be synchronized with horns. Spacing and location of audio/visual devices shall meet the requirements of ADA, NFPA 72 and all other applicable codes.

D. All circuits, both initiation and annunciation, shall have at least 25% spare capacity for additional devices. Wiring and conduit for the annunciation circuits shall not be shared with the wiring and conduit for initiation circuits.

E. Power Supply. Power to supply fire alarm systems shall be taken from the building service on the supply side of the main service switch. Where the building is supplied with an emergency generator, the fire alarm power supply shall be taken from the emergency distribution system.

F. The fire alarm system shall report to either a central station or the fire department. Coordinate the reporting requirements with the Contracting Officer or representative

6.13.3 Public Address Systems

Public address system design requirements are defined in the *Telecommunications Infrastructure Guidelines* and the ARS *Telecommunications Distribution Design Guide* found at http://www.afm.ars.usda.gov/facilities/files/PGM-06-001.doc.

Appendix 6A: Electrical Design Submission Requirements

6A-1. 15 Percent Electrical Design (Concepts) Submittal

A. Drawings

1) Plans showing equipment locations for major electrical, telecommunication, and security equipment to include: panels, switchboards, transformers, UPS, and generators, etc.

2) Provide a preliminary single line diagram of the proposed power distribution system.

B. Narrative

1) Description of the electrical distribution system.

2) Listing of applicable codes and code compliance statement.

3) Description of lighting and lighting system including design foot-candle levels and power density limitations.

4) Description of the proposed telecommunication, fire alarm, security and other low voltage systems.

5) Description of energy code and LEED compliance methods and strategies.

C. A-E Design Checklist

6A-2. 35 Percent Electrical Design and/or Conceptual Electrical Design submittals

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Lighting calculations and lighting fixture selections.

3) Load calculations.

4) Description of electrical, telecommunication, fire alarm, and security systems to include:

   a) Description of alternative power distribution schemes with recommendations. Include the source of power, potential for on-site generation, most economical voltage and primary versus secondary metering. Address special power and reliability requirements, including emergency power and UPS systems.

   b) Proposed lighting systems. Discuss typical lighting system features, including fixture type, layout, foot-candle levels, power densities, and type of controls. Discuss exterior lighting scheme.

   c) Interface with Building Automation System. Also, methods proposed for energy conservation and integration with Building Automation System.

   d) Description of proposed security systems' features and intended mode of operation. Proposed card access controls, CCTV assessment and intrusion protection system.

   e) Proposed Telecommunications Infrastructure. Systems proposed for infrastructure and cabling to accommodate the communications systems. These must be designed and provided in compliance with the ARS Telecommunications Distribution Design Guide.

   f) Description of other proposed low voltage signal systems.

   g) List of proposed energy saving measures.

5) Responses to the 15 percent Review Comments.

B. <u>Drawings and Specifications</u>

1) Site plan showing site distribution for power and communications, proposed service entrance and location of transformers, generators, and vaults, etc.

2) Floor plans showing: major electrical distribution equipment and electrical rooms; major pathways for communications system cabling, communications equipment rooms and locations for signal system head end equipment.

3) Single line diagrams of the building power distribution system and riser diagrams of signal system including fire alarm, data, telephone, security, public address, and other low voltage systems.

4) Site plan showing proposed locations for CCTV, duress alarm sensors, and access controls for parking lots. If the system is not extensive, these locations may be shown on the electrical site plan.

5) Security system floor plans. Proposed locations for access controls, intrusion detection devices, CCTV and local panels.

6) Lighting plans showing the location of lighting fixtures and control locations.

7) Power plans showing the location of receptacles and equipment requiring power.

8) List of specifications sections to be used.

C. A-E Design Checklist

6A-3. 50 Percent Electrical Design Submittal

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Narrative description of electrical, telecommunication, and security systems.

3) Illumination level calculations.

4) Short circuit calculations.

5) Voltage drop calculations.

6) Generator calculations. Include the effects of motor loads.

7) Equipment selections for major equipment (switchgear, switchboards, motor control centers, panelboards and unit substations, etc.)..).

8) Responses to the 35 percent Review Comments.

9) Description of techniques for harmonic current, mitigation with supporting calculations. Mitigation must address the effects of variable frequency drives on motors and motor bearings.

10) List of energy efficiency measures included in design, with a tabulation of energy usage in watts per square foot for the different types of spaces within the Project.

B. Drawings and Specifications.

1) Floor plans. Show lighting, power distribution, receptacle locations low voltage system raceway locations and locations of fire alarm panels, fire alarm devices, low voltage signal system head-end equipment, and low voltage signal system devices.

2) Marked-up specifications.

3) Preliminary schedules.

4) Single-line diagrams of primary and secondary power distribution. Include normal power, emergency power and UPS.

5) Single-line diagrams of fire alarm system.

6) Riser diagrams of low voltage signal system.

7) Circuit layouts of lighting control system.

8) Site plans. Indicate service locations, manholes, ductbanks and site lighting.

9) Layouts of electrical equipment spaces. Show all electrical equipment. Include elevations of substation transformers and disconnect switches.

10) Grounding details and diagrams.

11) Complete phasing plans (if required) for additions and alterations.

12) A security systems site plan. Final locations of all security devices and conduit runs.

13) Security system floor plans. Layouts of all security systems.

C. A-E Design Checklist

6A-4. 95 Percent Electrical Design Submittal

A. Design Analysis.

1) Any revisions from the 50 percent submittal.

2) Narrative description of electrical, telecommunication, and security systems.

3) Final equipment selections showing two manufacturers.

8) Responses to the 50 percent Review Comments.

9) Protective Device Coordination Study and Arc-Flash Analysis.

B. Drawings and Specifications

1) Essentially complete drawings and specifications with only minor coordination and technical issues to be resolved.

C. A-E Design Checklist

6A-5. 100 Percent Electrical Design Submittal

A. Design Analysis.

1) Complete design analysis incorporating the final calculations, narrative, equipment selections, review comments etc....

2) Responses to the 95 percent Review Comments.

B. Drawings and Specifications

Complete drawing and specification package suitable to "Issue for Construction."

C. A-E Design Checklist

Appendix 6B: Electrical Design Coordination Checklist

6B-1. 15 Percent Electrical Submittal Coordination

A. Drawings

1) Major electrical equipment is shown and identified.

2) Telecommunications head end equipment is shown and identified.

3) Preliminary single line diagram is complete.

B. Narrative

1) List of applicable codes are complete.

2) The electrical distribution system is explained with accompanying lifecycle cost analysis if required.

3) Description of lighting system is complete.

4) Descriptions of low voltage signal systems are complete.

5) The energy code and LEED compliance methods and strategies support the project requirements.

6) Electrical site work is shown schematically on the site plans.

7) A-E design checklist is completed.

6B-2. 35 Percent Electrical Submittal Coordination

A. Design Analysis

1) List of applicable codes is included.

2) Lighting calculations are complete and fixture selections are made.

3) Load calculations are provided.

4) Descriptions of electrical systems from the 15 percent submittal are included and updated.

   a) The analysis addresses power source, voltage selection, on-site generation, system reliability, alternative energy and special power requirements.

   b) The lighting system analysis includes lighting calculations, foot-candle levels, power densities and control methods.

5) List of energy saving measures is provided.

6) A-E design checklist is completed.

B. <u>Drawings</u>

1) Information required for the 15 Percent Submittal is included and updated.

2) Site plan are provided showing the power, communications and security system equipment and raceways.

3) Floor plans are provided showing:

   a) Major equipment locations.

   b) Pathways for communications system cabling.

   c) Communications equipment spaces.

   d) Location of low voltage signal system head end equipment.

   e) Location of security devices such as cameras, access controls and intrusion detection devices.

4) Single line diagram shows the electrical distribution equipment with sizing information.

5) Preliminary riser diagrams are provided for low voltage signal systems.

6) List of Specifications is provided.

7) Responses to the 15 Percent Review Comments are included and incorporated.

6B-3. 50 Percent Electrical Submittal Coordination

A. Design Analysis

1) Information provided in the 35 Percent Design Analysis is included and updated.

2) Preliminary short circuit calculations are provided.

3) Generator calculations are provided.

4) Preliminary voltage drop calculations are provided.

5) Equipment selections for major equipment are provided.

6) A-E design checklist is completed.

7) Harmonic current mitigation information is provided.

8) Energy saving measures are listed and energy usage information is provided.

B. Drawings

1) Information required for the 35 Percent Submittal is included and updated.

2) Floor plans are provided showing:

a) Receptacle locations.

b) Low voltage system device locations.

c) Fire alarm device locations.

3) The electrical rooms and spaces are of sufficient size and correct construction to meet code and equipment requirements.

4) Telecommunication rooms and spaces are of sufficient size and correct construction to meet code and equipment requirements.

C. Marked-up Specifications are provided for all electrical work.

D. Reponses to the 35 Percent Review Comments are included and incorporated.

6B-4. 95 Percent Electrical Submittal Coordination

A. Design Analysis

1) Information provided in the 50 Percent Design Analysis is included, updated and finalized.

2) Two manufacturers are listed for equipment that has been selected.

3) Protective Device Coordination Study is provided.

4) Arc Flash Analysis is provided.

B. Drawings

1) Drawings are complete with the necessary details, diagrams and sections to depict the work that is necessary. Demolition drawings are complete showing all work that necessary.

Drawings have key plans, graphic scales, and north arrows as appropriate.

Lighting fixtures and the electrical ceiling features are coordinated with the architectural ceiling plans.

Power, controls and disconnecting devices for HVAC, plumbing , architectural and other equipment is shown and coordinated.

The NEC electrical clearance requirements are satisfied.

The electrical design complies with all applicable codes.

The legend or list of symbols is complete.

Schedules are complete.

2) Penetrations through fire rated and biocontainment walls and floors are indicated and detailed.

C. Specifications are complete. All items on the drawings are specified.

D. Responses to the 50 Percent Review Comments are includes and incorporated.

6B-5. 100 Percent Electrical Submittal Coordination

A. Design Analysis is complete and 95 Percent Design Review comments are incorporated.

B. Drawings are complete and 95 Percent Design Review comments are incorporated.

C. Specifications are complete and 95 Percent Design Review Comments are incorporated.

7. SAFETY AND HEALTH ELEMENTS

7.1 GENERAL

7.1.1 Purpose and Objective

A safe and healthy work environment is the crucial objective in the design of agency facilities. The requirements listed in this Chapter are the minimum agency requirements to meet this objective. Unless specific reference is made otherwise, all codes and standards cited in this chapter shall be the latest editions. Both NFPA Life Safety Codes and model building codes permit equivalency concepts.

All deviations from this document and any equivalency concepts proposed for use, must be identified by the A-E and submitted to the Government for approval no later than the 35 percent design stage. Submission shall be made through the Engineering Project Manager (EPM) for Facilities Division (FD) projects, or Area Office Engineer (AOE) for Area projects. The request must state the deviation/equivalency concept proposed, reasons for the request, and supporting rationale. The EPM or AOE will coordinate the request with the appropriate office and provide a response to the A-E.

7.1.2 Definition of Laboratory

A laboratory is defined as a building space, room or operation used for testing, analysis, research, instruction, or similar activities. An area, exclusive of maintenance shops, is considered a laboratory if any of the following exists.

A. Fume hood/Biosafety cabinets or other primary barriers.

B. Incidental use or storage of chemicals with any of the following properties: flammable, combustible, explosive, water sensitive, caustic, corrosive, high or unknown toxicity, carcinogen.

C. Biohazardous material.

D. Grinding operations (excluding metal).

E. Radioactive material/ionizing radiation emanating equipment.

7.1.3 Codes and Special Requirements

A. Requirements relating to safety and health in the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA) regulations, American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual, Standards of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), ARS safety and health policy, and local building and fire codes must be met as a minimum to achieve a safe and healthy work environment. Where a conflict arises, the most stringent requirement shall govern.

B. Department of Labor Standards. The project shall be designed to comply with the latest versions of the applicable OSHA Standards (29 CFR Part 1910) and Safety and Health Regulations for Construction (29 CFR Part 1926) as promulgated by the Department of Labor.

C. National Fire Protection Association Codes. The project shall be designed to comply with the most current edition of the National Fire Code, as promulgated by the NFPA.

D. U.S. Department of Health and Human Services Biosafety Guidelines. The project design shall be in compliance with the latest revision of the applicable Biosafety Guidelines (promulgated by the Centers for Disease Control and Prevention (CDC), and National Institutes of Health ((NIH) applicable to the level and nature of the project research activities. (Specific guidance for biohazard containment design can be found in CHAPTER 9.)

E. USDA. Radiation Safety Division. The project shall be designed to comply with the latest Nuclear Regulatory Commission regulations (contained in 10 CFR 20), ACGIH, and license conditions where appropriate.

F. Laboratory Chemical Fume Hoods Standards. The project shall be designed to comply with the latest revision of the ACGIH and ANSI/AIHA (American National Standard Institute/American Industrial Hygiene Association) Z9.5, as well as specific requirements of this CHAPTER.

G. American National Standards Institute. The drawings and specifications for each project shall show and require safety and health construction features and practices which conform to the most current ANSI Standards noted in the ANSI Safety and Health Index, Publication 5P8L-PC20M1085.

H. Model Building Codes. The project shall be designed in accordance with the prevailing Model Building Codes (UBC, BOCA, SBC, IBC) enacted in the project area.

7.2 ELEMENTS OF DESIGN

7.2.1 HVAC System

The HVAC system shall be designed with at least the following minimum requirements: (Where a conflict arises, the most stringent requirement shall govern.)

A. Separate HVAC systems shall be provided for laboratory areas, animal holding areas, and non laboratory administrative areas.

B. Ventilation requirements for electrical shops, photography laboratories, and other special use areas shall be as prescribed in the applicable ASHRAE Standards.

C. A minimum of 15 air changes/hour is required for animal facilities including independent temperature and humidity controls. Recirculation of exhaust air from animal facilities is prohibited. (Refer to Chapter 10 for guidance in the design of animal research and care facilities.)

D. A minimum of 8 air changes/hour is required in laboratories and recirculation of exhaust air from laboratories is prohibited.

E. All other areas shall be provided with an adequate level of fresh air in accordance with ASHRAE Standard 62, *Ventilation for Acceptable Indoor Air Quality*.

F. HVAC systems must not employ ozone depleting substances. This includes new construction as well as renovation of existing systems

7.2.2 Laboratory Ventilation

The provisions of NFPA 45, ASHRAE, ANSI/AIHA and ACGIH for ventilation and fume hoods shall be strictly adhered to. Where a conflict arises, the most stringent requirement shall govern. (For design of biohazard containment facility, refer to Chapter 9.)

A. Except for certain biocontainment applications, the air pressure must be negative relative to the corridors or other common use spaces. Hallways and corridors shall not be used as return air plenums, and louvers will not be permitted in fire rated doors. (Refer to Chapter 9 for Biohazard Containment Design.)

B. All exhaust air shall be ducted. Interstitial space shall not be used as a plenum to exhaust laboratory areas.

C. Recirculation of laboratory air is prohibited.

D. Supply air diffusers shall be placed so as not to interfere with the function of fume hoods. Supply air diffusers and exhaust inlets shall be placed so that the room is swept by the air with short circuits being avoided. (Refer to ASHRAE and ANSI/AIHA for additional information.)

7.2.3 Fume Hood Requirements

All laboratory chemical fume hoods and exhaust systems shall comply with ACGIH and ANSI/AIHA guidelines as well as the guidelines presented in this Chapter. Surfaces must be durable and easily cleanable. Service outlets shall be located so that the operator will not have to reach into the hazard zone to make connections. Variable Air Volume (VAV) hoods shall be the primary choice of hoods in new construction or renovation. Bypass hoods may be used if VAV is not proven cost effective. (Refer to Chapter 5 for requirements for energy conservation and refer to Chapter 9 for biohazard containment design.)

A. Fume hood design airflow shall be determined by the specific program requirements of the hood, which shall be determined during the Program of Requirements. Unless there are specific program requirements, the design sash position for hoods shall be 18 inches. The design airflow shall be determined using the design sash position and 100 fpm as the design face velocity.

Automatic sash closing devices shall be installed if Life Cycle Cost Effective.

“As balanced” face velocities shall be 100 fpm for fume hoods (80-120 fpm is the operational range) “As balanced” face velocities for fume hoods used as radioisotope hoods shall be a minimum of 100 fpm.

B. <u>Stack heights</u> shall be determined by the height of the building (building envelopes), proximity to other buildings, local topography, prevailing winds, and weather conditions. The minimum stack height shall be 3 m (10 ft.) from the plane of the roof. The minimum exhaust velocity shall be 15 m/s (3000 fpm) at the discharge point of the exhaust stack. The A-E shall verify via modeling that the 10-foot minimum height requirement is adequate. If proven by the Computer Flow Dynamic (CFD) model, that a stack height of less than10 feet is acceptable, a wavier must be submitted for Government approval.

Aesthetic objections to high stack heights shall be overcome with architectural treatment. An exhaust tower or a cluster (bundle) of exhaust stacks can be made an element of the building and is an acceptable method of achieving this. The bundling of exhaust stacks has the added advantage of creating a plume of exhausted gases which is less readily deflected from upward vertical flow by wind gusts. The use of cone-style weather caps is prohibited.

Exhaust stacks and air intake inlets shall be located at appropriate distances from each other in order to provide proper dilution and no recirculation of exhausted air. (See ASHRAE Standard for additional guidance.)

C. Hood locations must be away from doors, windows, and occupant traffic. Where fume hoods or Biosafety cabinets are placed opposite one another, the design shall take into consideration egress and aerodynamic considerations.

D. <u>Manufacturer Certification</u>. The laboratory hood manufacturer shall provide certification that the unit performs satisfactorily under the condition required by the design documents.. The designer shall clearly define the requirement for a report and certification of the "As Manufactured" ANSI-ASHRAE 110 Defined Performance Test Data in the project specifications. This report will show the hood(s) to be used in the project have been tested and passed the ANSI-ASHRAE 110 Performance Test Data.

E. The "As Installed" testing for new hoods shall follow the ANSI/AIHA Z9.5, 2003, or the latest edition. In general the tests shall consist of the following:

a. Fan Performance Tests
b. Exhaust Duct Measurements
c. Hood Performance Tests
d. Hood Monitor Calibration
e. Multiple sash flow tests, including Response and Stability Tests (VAV hoods)

7.2.4 Fume Hood & Laboratory Unit Exhaust Requirements

In accordance with NFPA 45, exhaust ducts from chemical fume hoods and other exhaust systems within the same laboratory unit shall be permitted to be combined within that laboratory unit.

Laboratory units will have individual exhausts or multiple laboratory units can be manifolded provided a redundant fan for manifolded systems is provided. Laboratory units manifolded shall be analyzed for compatibility. Manifolding laboratory units will be limited to the number of hoods supplied by a single air handling unit, but should not exceed 20. If more than 20 fumehoods are projected to be manifolded, a waiver will be required. See section 7.1.1 for procedures to document a deviation request.

Laboratory exhaust systems shall be designed to operate on a 24-hour basis. Set back of laboratory unit exhaust systems to four air changes/hour shall be implemented, preferable by occupancy sensors. Where chemical storage cabinets are power ventilated, the laboratory HVAC system volume of air flow can be reduced, or "set back," during those hours when the laboratory is not occupied.

Fans must be installed so that all ducts within the building are maintained under negative pressure. Where fans are located in fan rooms, the fan rooms shall be kept under negative pressure to the rest of the building. Refer also to the latest NFPA 45.

7.2.5 Radioisotope Fume Hood

All laboratory fume hoods for radioisotope work shall be designed in compliance with ACGIH; all bench top, sink, and floor material must be durable and easily cleanable (coved corners and joints); all service outlets shall be located so that the operator will not have to reach into the hazardous zone to make connections; and the appropriate filters shall be included.

7.2.6 Perchloric Acid Hoods

Perchloric acid hoods shall meet the criteria identified in NFPA 45 and ACGIH. If perchloric acid hoods are not required in accordance with the POR for current research needs, but could be required in the future, as determined by the project's Research Program Representative, the A-E shall incorporate into the design package, as a minimum, one rough-in (i.e., ductwork and plumbing hookup).

7.2.7 Biological Safety Cabinets

Only vertical laminar flow biological safety cabinets shall be used in agency facilities. The class II biological safety cabinets shall comply with NSF/ANSI Standard 49 for class II laminar flow biological safety cabinet to provide personnel; environmental; and product protection; horizontal and/or vertical laminar flow cabinets (clean benches) shall not be installed.

If the scientific program requires the use of laminar flow cabinets, a waiver shall be submitted to the Government for approval.

Selection of the Biological Safety Cabinet's Class shall be determined by the program base on the program risk assessment during the initial project planning.

7.2.8 General Purpose Hoods

Hoods for all other purposes shall be designed in accordance with ACGIH and ANSI/AIHA.

7.2.9 Incinerators

Incinerators shall meet or exceed all State, local, Environmental Protection Agency and National Fire Code requirements. It is crucial that incinerators for radioactive materials shall meet or exceed Nuclear Regulatory Commission and all applicable codes and/or requirements such as 40 CFR 60. Permitting process/requirements will be identified during the design process by the design A-E.

7.2.10 Chemical Storage

Laboratories which use flammable/combustible materials and chemicals shall provide adequate storage in a segregated, storage cabinet in accordance with NFPA 30 and NFPA 45. If the cabinets must be vented, venting shall be accomplished in accordance with NFPA 30 and 45.

A. In each laboratory where corrosive materials will be used, there shall be a segregated corrosive material vented storage cabinet. Use corrosion resistant materials suitable for their intended use.

B. Provisions for storage of carcinogenic chemicals in each laboratory shall be in accordance with the applicable OSHA standards in 29 CFR Part 1910.

C. Compressed gases shall be manifolded at a central location closest to those laboratories they serve. Efforts shall be taken to avoid extraneous use of gas cylinders in laboratories.

D. The design of any area for the express purpose of storage of compressed gases and flammable combustible materials shall comply with OSHA Standards in 29 CFR 1910, Subparagraph H, Hazardous Materials; NFPA 30; NFPA 45, and Compressed Gas Association, Pamphlet P-1.

<u>Note</u>: The design of separate chemical storage is an issue that should be considered during the POR/concept design. The intention is to not mandate the use of separate chemical storage rooms.

7.2.11 Additional Exits

Each laboratory shall have an additional means of exit remote from the primary exit. Adjacent laboratories may share this remote exit via a common separation wall. Mechanical equipment rooms, boiler room, and furnace room shall have an additional means of exit, remote from the primary exit. The A-E shall provide, as part of the first submittal, a conceptual layout identifying the additional means of exits.

7.2.12 Occupancy Classification

A. Agency structures must be classified in accordance with the established local building codes of the jurisdiction in which the structure is to be located. In addition to local building codes, the agency has set the following additional requirements for all laboratories as previously defined. The POR developed by the A-E will include a list of all applicable codes and the name and address of the local code authority. (Refer to NFPA 101, NFPA 41, and NFPA 45, for additional information.)

B. Dead-end pockets in hallways, corridors, passageways, or courts are discouraged. However, in no case, will any such pocket exceed code allowances.

C. Travel distances for high hazard areas (NFPA 101, 5-11.1) and high hazard laboratories (NFPA 45, 2.2, Table 2.2) will not exceed 23 m (75 ft.). Travel distances from all other laboratories shall not exceed 45 m (150 ft.).

D. All laboratories (refer to section 7.1.2 above), shall be designed in accordance with NFPA 45. Laboratory exit corridors will not be used as "exits" in order to increase travel distances along exit access routes to exit stairs or ramps. Where stair enclosures are part of a design, it is the agency's policy to make these stair enclosures the primary protected means of egress from a building.

E. As part of <u>the first submittal</u>, the design firm must document coordination with code officials and provide for the agency's review, a code analysis addressing building classification and requirements.

7.2.13 Emergency Eye/Face Wash and Shower Station

Each laboratory, chemical storage room, chemical handling room, pesticide storage, mix and load areas, shall have an emergency eye/face wash and shower in accordance with ANSI Z358.1 (latest edition), Emergency Eyewash and Shower Equipment.

A. Wall-mounted portable units and hand-held single-head devices are not acceptable in lieu of stationary dual-head eye washes.

B. Emergency showers shall be located within 30 m (100 ft.) or 10 seconds travel time from a potential injury source. Showers should be installed closer to the potential injury sources if such sources are highly corrosive chemicals. Emergency shower stations should provide natural screening where possible.

C. Eye wash stations may be installed as integral components with laboratory sinks or the emergency showers, so long as accessibility standards are maintained.

D. Emergency showers and eye/face washes shall have stay-open actuation valves, to allow operators free use of both hands once the flow of water has begun. Emergency shower/eye wash station shall be provided with tepid water. ANSI Z3581.1 – 2004 recommends that tepid water be between temperatures of 60° F to 100° F. One tempering water valve shall be supplied for each emergency station. If the AE can document that water supply in the area will always stay within the tepid range, the AE can request a waiver to not provide tempering water valves.

E. Each laboratory shall have a floor drain, co-located with the emergency shower.

7.2.14 Laboratory Furniture

Laboratory furniture shall be designed such that:

A. It is corrosion resistant;

B. Contamination removal from surfaces is not difficult;

C. It is arranged so as not to impede egress in an emergency; and

D. The working surface is free from cracks and sensible joints.

7.2.15 Health Hazards

A. Asbestos. All work involving asbestos-containing materials shall be performed in accordance with OSHA standards contained in 29 CFR Part 1910.1101, as applicable, as well as those Federal and State EPA regulations that pertain to asbestos-containing material maintenance and abatement.

B. Lead Base Paint (LBP). All work involving LBP materials shall be performed in accordance with OSHA standards contained in 29 CFR Part 1926.62, as applicable, as well as those Federal and State EPA regulations that pertain to LBP material maintenance and abatement.

C. Mold. All work involving mold remediation shall be performed in accordance with applicable OSHA regulations, US Environmental Protection Agency (EPA) regulation 402-K-01, and applicable state regulations.

D. Mercury Containing Light Bulbs and PCB Light Ballasts. Shall be handled in accordance with applicable state and federal regulations.

7.2.16 Fire, Smoke and Heat Safety

A. Portable Fire Extinguishers. The appropriate number, types, and locations of fire extinguishers must be provided in accordance with NFPA 10, "Portable Fire Extinguishers." Whenever possible, the 10- pound ABC Multipurpose fire extinguisher shall be provided in a recessed cabinet and located in the corridors. Halogenated (Halon 1211 or 1301) fire extinguishers will not be used.

B. Fire, Heat and Smoke Detection Systems. All corridors, meeting rooms, and storage rooms will be protected by fire detectors. When required in other areas by code, automatic fire detectors will be installed. If the structure cannot be protected by a fire suppression system, a complete automatic fire detector system is required. Automatic fire detectors shall be located, mounted, tested, and maintained in accordance with NFPA 72.

C. Fire Suppression Systems. Fire suppression systems shall be designed and installed in accordance with federal, state, or local codes. It is ARS' policy to install sprinkler systems in all laboratory facilities. Fire suppression systems must not employ ozone depleting substances. This includes new construction as well as renovation of existing systems.

D. Fire Alarm Systems. Fire alarm systems shall be installed in accordance with NFPA 72. A manual fire alarm system (at a minimum) will be installed in a structure if a fire may not, of itself, provide adequate warning to building occupants.

E. Miscellaneous

1) Standpipes, in accordance with NFPA 14, will be installed in laboratory buildings of two or more stories above or below street level.

2) HVAC smoke control must be used if mandated by NFPA 90A.

3) The locating of storage and handling of flammable liquids and gases

where it would jeopardize egress from the structure will not be permitted.

7.2.17 Animal Facilities

Special consideration shall be given to the design of individual animal rooms. Design must ensure that all research animals are protected to prevent transmission of diseases between animals and from humans. (Refer to Chapter 10 for requirements)

8. VERTICAL TRANSPORTATION SYSTEMS

8.1 GENERAL

8.1.1 Scope

This Chapter deals with design requirements for vertical transportation systems for Federal buildings.

8.1.2 Codes and Standards

A. New vertical transportation equipment installations shall comply with the American Society of Mechanical Engineers (ASME) Life Safety Code for Elevators and Escalators, A17.1/CSA B44-07 (herein referred to as the A17.1 Code), the current Architectural Barriers Act Accessibility Standard (ABAAS), and the International Building Code (IBC). Existing elevators or vertical transportation equipment shall be improved as appropriate to conform to the A17.1 Code. See Chapter 1: *Basic Requirements* for complete discussion of codes and other special requirements. The current edition of each applicable code, in effect at the time of design contract award, shall be used throughout the project's design and construction. This includes adherence to the appropriate rating/load classification for the proposed application.

B. Conflict Between Codes and ARS Requirements. The code criteria shall be reviewed by the A-E to the degree of detail necessary to assure that tasks accomplished during the architectural design of a project meet the code requirements. All deviations from code/ARS requirements and any equivalency concepts proposed for use must be identified by the A-E and submitted to the Government through the EPM for approval no later than the 35 percent design stage. The request must state the deviation/equivalency concept proposed, reasons for the request, and supporting rationale. The EPM will coordinate the request with the appropriate office and provide a response to the A-E.

8.1.3 Guidelines/Coordination

The A-E is recommended to hire an independent consultant to perform objective studies on the number and type of vertical transportation systems needed at the facility, and to ensure compliance with all applicable codes. The traffic analysis shall determine the quantity, capacity and speed requirements of elevators. Separate calculations shall be made for passenger and for freight or service (combination of passenger and freight) traffic. The vertical transportation system design shall be coordinated with the architectural, structural, mechanical and electrical design. On alterations projects, the A-E shall make such visits to the site as are necessary to ensure coordination with existing work. Electric traction elevators are preferred for both passenger and freight applications; hydraulic systems may be considered for low-rise facilities or where overhead clearance is limited.

8.2 DESIGN REQUIREMENTS

8.2.1 Passenger Elevators

A. Location. Elevators shall be located so that they are easily accessible and convenient to circulation routes, and so that the building entrances with the heaviest traffic will have adequate service. They shall be located so that the travel distance from an office or workspace to an elevator does not exceed 200 feet.

B. Size and Number. The size and number of elevators required for a given facility depend on multiple factors including cost, net area, population density, and maximum traffic peak.

1) Cost. The overall annual cost of the elevator facilities, including amortized cost of the original investment, maintenance, material, and consumed power.

2) Net Area. This is the floor area of the building served by the elevators exclusive of the main (street) floor mechanical and electrical rooms, parking areas, cafeterias, stairways, toilets, corridors, and similar areas.

3) Population Density. This is the net area per person. The A-E shall estimate the building populations above the main floor on the basis of 135 sq. ft. net area per person. However, the vertical transportation systems shall be planned for the total population that the facility could reasonably support in the future.

4) Maximum Traffic Peak. This is the maximum percentage of the total population that shall be handled during any five-minute period. The maximum traffic peak will vary based on the type of functional spaces within the facility; the computations shall be based on transporting a minimum of 10% of those persons during periods of maximum demand in 5 minutes. In general, the maximum traffic peak shall be considered as that produced by the morning filling of the building.

C. Traffic Distribution. Elevators shall be grouped in banks of at least two for efficiency, and groups of elevators serving identical floors are required to be furnished at two or more locations to provide reasonable convenience of use. The elevators shall provide a minimum carrying capacity of not less than 120 percent of the maximum traffic peak. This factor provides for the unequal distribution of traffic when elevator groups occur at more than one location. Calculations based on the above factors shall be submitted as part of the design concept submission where two or more passenger elevators are required.

D. Capacity, Speed, and Interval. A capacity and speed shall be selected that will require the least number of passenger elevators to handle the peak load with an acceptable time interval of dispatch. The average peak period loading shall be assumed as 80 percent of rated car passenger carrying capacity based on an average passenger weight of 160 pounds. For office buildings, the most suitable car capacities are from 3,500 to 4,000 pounds
Where there is only one elevator in the public building, it shall have a minimum capacity of 4,000 pounds and shall be classified as a combination passenger and freight elevator.

The A-E shall design the system on the basis of a 35 second response waiting time interval between elevators.

E. Disabled Considerations. Passenger elevators shall be designed to accommodate individuals with physical disabilities. Individual markers shall not be accepted. Characters on car operating panels and call button stations shall be cut into the faceplate as an integral part of faceplate.

F. Combination Passenger and Freight Elevators. If a separate freight elevator is not provided, requirements for freight service shall be considered in determining the number and duty of elevators. Door opening width shall be coordinated with the agency to accommodate the anticipated freight. Combination passenger and freight elevators are not recommended when freight movement would interfere unduly with passenger service. Consideration shall be given to increasing cabinet height when elevators are used for combination passenger and freight.

G. Continuity of Service. When one elevator normally would meet the requirements in a building where elevator service is essential (such as office buildings more than two stories high), two shall be installed to ensure continuity of service. If budget limitations preclude a second elevator, as a minimum, a hoistway for a future elevator shall be provided.

H. Fire Protection. Elevator fire safety design shall meet the latest version of the A17.1 code. Smoke detectors shall be provided in each elevator lobby and landing, in addition to all elevator machine rooms; they shall not be installed at the top of the elevator shaft/hoistway. The activation of a smoke detector shall cause all elevators to return nonstop to the designated level; if the detector at the designated level is activated, the elevators shall return to an alternate level previously approved by the Fire Marshall.

I. Security. Elevator control panels shall have lockout provisions for all floors. Key locks, card readers or coded key pads, integral with the elevator control panel, shall be provided to override lockout. A non-propriety control system for elevator security systems should be used.

J. Finishes. Elevator flooring needs to be extremely durable or easily replaceable; low pile height/high density carpet, wood or high quality resilient materials are preferred. Walls and doors shall be scratch resistant and easily replaced or re-finished. Drop ceilings shall be provided, along with recessed downlights or indirect fixtures.

8.2.2 Freight Elevators

A. Classification

1) General Freight. These are provided to handle the common freight requirements of activities in the building. The material transported by these elevators is distributed throughout the building.

2) Special Purpose Freight. These serve the particular requirements of one activity in the building. These elevators form a part of a planned route for handling a specific type of material. An animal research facility is an example of when such elevators would be utilized, where dedicated “clean” and “dirty” animal elevators may be required. These types of applications require coordination with the USDA to ensure compliance with the program requirements, while complying with the A17.1 code.

B. Planning. When planning the location of freight elevators, the following principles shall be observed:

1) General freight shall be arranged to discharge into a separate vestibule or service lobby at each floor, but shall not discharge into primary routes of horizontal circulation such as main corridors, lobbies, etc.

2) Freight elevators shall be located convenient to the building loading platform or to other facilities provided for bringing freight into the building.

3) A freight elevator shall have a stop at the major mechanical and electrical equipment level(s), including equipment levels of other elevators.

C. Size and Number

1) Special-Purpose Freight Elevator. The size and number of special-purpose freight elevators will depend upon information received from the agency regarding the kind, total load, method of loading, and movement of freight that must be handled. The design shall comply with the A17.1 code for the appropriate freight elevator class.

2) General Freight Elevators.

a) The size of general freight elevators shall be adequate for the movement of essential freight, including re-locatable partitions. The platform size shall be not less than 8 feet wide by 12 feet deep, and should have a ceiling height not less than 12 feet (solid walls required for a minimum height of 6 feet). A larger size, adequate for the intended use, shall be provided wherever investigation shows that the elevator shall be used to move mechanical equipment, fork lift trucks, or other materials. Horizontal sliding type doors shall be provided.

b) At least one general freight elevator shall be provided in office buildings that have a gross area of 250,000 square feet or more, and have three stories or more above ground. The installation of a freight elevator shall be made when the conditions of occupancy indicate that service is needed regardless of the size of the building.

D. Capacity and Speed. Freight elevators shall be designed in accordance with the A17.1 code for a class “C1" loading. Freight elevators shall have a car speed in proportion to the number of floors served.

E. Continuity of Service. If continuity of service is necessary, two freight elevators shall be installed, even if normal service demands are handled satisfactorily with one.

F. Finishes. Flooring shall be resilient vinyl tile. Walls and doors shall be very durable and easy to clean; stainless steel is preferred. Ceiling light fixtures must be recessed and protected from potential damage.

8.2.3 Elevator Hoistways

A. Framing. The hoistway shall be free of projections. Framing projections which occur shall have guard plates as required by the A17.1 Code. Structural supports shall be provided at each floor and, where conditions require, between floors for securing guide rail brackets.

B. Enclosures. Elevator hoistway enclosures shall be of fire-resistant construction. The interior face of hoist way enclosure walls shall have a smooth, flush, light-colored surface, equivalent to well-pointed smooth face tile or brick, or smooth concrete. Sprayed-on fireproofing shall not be used in the elevator hoistway and machine rooms.

C. Windows and Skylights. Windows are prohibited in the hoistway; skylights are permitted.

D. Hoistway Ventilation. Hoistway ventilation shall be provided for venting smoke and hot gases to the outside air in accordance with the Basic Building Code, National Building Code, Standard Building Code, or the Uniform Building Code.

8.2.4 Elevator Pits

A. Depth Requirements. Pit depths should comply with the A17.1 Code requirements.

B. Access

1) Each pit with a depth between 3 feet and 8 feet shall be provided with a fixed vertical steel access ladder. The ladder shall be located within reach of the elevator hoist way entrance at the bottom landing and to clear elevator equipment.

2) Pits 8 feet deep and over shall be provided with a permanent means of external access, preferably a stairway and door to each pit. Where a permanent means of access is impractical, a permanent ladder, accessible from the hoist way entrance at the bottom, shall be provided in each pit; however, the external access must be very carefully studied before it is declared impractical.

3) Adjacent pit spaces shall be separated by a 7-foot high wire mesh partition.

4) Doors to pit spaces shall be of fire-resistant construction, and shall be provided with self-closing, self-locking hardware, arranged so that a key is required for entry. The doors shall swing out, and offer no impedance to exiting.

C. Fire-Resistance Requirements. The pit must be enclosed with fire-resistive construction not less than that which is required for the hoistway. Where the elevators in one bank or one group of elevators are located in two separate fire-resistant hoistways, the pit space for the group of elevators shall be similarly divided into two fire-resistant units.

D. Drainage. Proper drainage shall be provided within the elevator pit, including sump pumps, drains, and gratings in locations and sizes per the A17.1 code. The sump pump shall be connected to the nearest acceptable sanitary line.

E. Stop Switch. A manually operated, enclosed pit stop switch must be provided for each elevator, and located adjacent to the nearest point of access.

8.2.5 Elevator Machine Rooms

A. Location. The placing of electric traction elevator machines in basement machine rooms, or in machine rooms adjacent to the shaft shall be avoided. This type of installation is not economical, as both first cost and recurring cost for maintenance and power are higher than overhead machines.

B. Features

1) Machine rooms in new buildings shall be large enough to install the elevator equipment, including space for disconnecting means, etc.; adequate sight lines for technicians shall be provided. Allow clearances for control equipment not less than required by the NEC, and with enough working space between the various items of equipment for maintenance purposes. In general, provide not less than 3 feet as the absolute minimum clearance between items of equipment. In new buildings, it shall be possible to remove major equipment components of one elevator for repair without dismantling components of an adjacent elevator. In existing buildings, it may not always be feasible to expand the elevator machine room so as to house the new equipment in accordance with the A17.1 Code.

2) Space shall be provided in machine rooms for tool cabinets, spare-parts cabinets, and lubricant racks or cabinets.

3) Elevator machine rooms shall be of fire-resistant construction, and shall be designed with a wet-pipe sprinkler system using standard response sprinklers. The machine room floor, ceiling, and walls shall have a smooth surface. Exposed sprayed-on fireproofing shall not be used in elevator machine rooms and hoist way. Walls, ceilings, and floors shall be painted a light color.

4) Sprinkler protected elevator machine rooms containing elevator control equipment shall be provided with a means to disconnect automatically the main line power supply to the affected elevator prior to the application of water in accordance with the requirements in NFPA 72.

5) In buildings where elevator mechanics will be employed, shop space shall be provided. If there is more than one machine room in the building, this shop space shall be provided in one location only.

C. Provisions for Removal of Equipment

1) If there is more than one elevator in a machine room, the freight elevator shall serve the machine room level. If not, a trap door shall be provided in the machine room floor to allow lowering of elevator equipment to the top floor served by the elevator. A trolley or hoist beam able to support the largest item of the elevator equipment shall be provided over the trap door and over each hoisting machine for removal of equipment.

2) In existing buildings, where there is only one elevator in the building, provisions shall be made so that major equipment components can be moved for repairs. Removal to the roof of the building, and then to the ground, by crane may be necessary.

D. Access

1) Entrance Door. The elevator machine room door shall be the self-closing, self-locking type provided with a cylinder lock that requires a key for entry. The door shall swing out and offer no impedance to exiting, and preferably not require an access route across a roof or other exposed area.

2) Stairs. Stairs shall be provided for convenient access to machine rooms in accordance with the A17.1 Code.

E. Noise Control

1) Acoustical Classification. Machine rooms are classified as Class X space.

Machine rooms that are on the same level with offices or similar spaces shall be provided with partitions of sufficient sound attenuation to prevent objectionable noises from reaching the occupied spaces, and to prevent interference with building electronic equipment.

2) Vibration and Sound Isolation. Geared machines and motor generator sets shall be mounted on vibration and sound isolating devices.

3) Lighting. Sufficient lighting shall be provided to ensure proper illumination in the front and rear of all controllers, panels, and over each hoisting machine.

4) Heating. Heating shall be provided in elevator machine rooms as required to meet the A17.1 code; steam or hot water unit heaters are generally provided.

5) Ventilation. Machine rooms shall be provided with ventilation as to limit space temperature rise to 10 ^{o}F. EMRs with electronic equipment may require air conditioning instead of ambient ventilation; the A-E shall define criteria for these spaces and design accordingly. As per the A17.1 code, no building systems shall be located in an EMR unless they serve the space.

8.2.6 Escalators

A. When vertical transportation is required for a large volume of traffic, escalators may be installed, only where absolutely necessary, to supplement elevators. Their use shall be justifiable for buildings with large floor areas, buildings with entering traffic at two or more levels, and service to special areas such as cafeterias and auditoriums. Escalators shall not be installed as a substitute for fixed stairs or as a substitute for elevators. If installed, they shall be in addition to, not in place of, required means of vertical movement.

B. Escalators shall be located convenient to building entrances or cafeterias, auditoriums, etc., and shall be located where they are prominently in view between elevators and building entrances so that a maximum portion of the total traffic will be diverted to them. It is recommended that escalators be located in a crisscross arrangement.

8.2.7 Dumbwaiters

A. Classification. Floor loading types or counter loading type.

B. Planning. Dumbwaiters shall be located convenient to the areas served, preferably in a position where the hoist way construction will not interfere with space use.

C. Size and Number. Dumbwaiter platform area and height must be adequate to permit convenient loading and unloading of materials. The number of dumbwaiters to be installed shall be based on the estimated volume of material to be handled.

D. Capacity and Speed. The dumbwaiter load capacity shall be adequate to handle the maximum anticipated car loading. Kitchen and library dumbwaiters have capacities of 500 pounds. Floor loading type dumbwaiters shall be designed to carry food carts, book carts, etc. Food-carrying dumbwaiters shall be made of stainless steel.

E. Types. Dumbwaiters shall be of the power-operated type.

F. Hoistways

1) Enclosures. Dumbwaiter hoistway enclosures shall be of fire-resistant construction with a smooth interior finish.

2) Entrance Doors. The dumbwaiter hoist way entrance doors shall be of fire-resistant construction and preferably of divided counterbalanced type. The entrance frames shall be, rolled or pressed sheet metal with an extended sill on the room side. Stainless steel frames and door panels shall be used for kitchen dumbwaiters. Doors and frames of sheet steel shall be factory made. Doors and frames of sheet steel shall be factory primed with painted finishing coats applied at the site. Dumbwaiter hoist way entrances located with sills at floor level shall have 1/4-inch thick, nonskid steel plate sills with a reinforced truckable sill on the top of the lower door section. In some installations, doors may be power-operated.

3) Size and Clearance. Hoist way sizes and entrance dimensions shall comply with the A17.1 Code. A swing type pit access door is desirable for cleaning out the pit for counter loading type dumbwaiters.

4) Machine Spaces. Dumbwaiter machine spaces shall be large enough to permit easy access to the equipment for maintenance purposes. The walls, floor, and ceiling enclosing the machine space shall be of fire-resistant construction.

5) If a hoist way tower is needed, it may consist of double sheet steel panels,

each with 18-gauge minimum. It shall be filled with sound deadening and fire-resistant materials.

8.3 ADDITIONAL EQUIPMENT

8.3.1 Wheelchair Lifts

A. Codes and Standards. Wheelchair lifts and stairway chairlifts shall conform to the latest edition of the American Society of Mechanical Engineers (ASME) Safety Standards for Platform Lifts and Stairway Chairlifts A18.1

B. Classification. Vertical wheelchair lift of inclined wheelchair lift.

C. Planning. Where ramp or elevator installations for use by individuals with physical disabilities are impractical, vertical and/or inclined wheelchair lifts shall be considered. The number and location of such lifts depend on the general architecture of each building, and shall be determined on an individual project basis.

D. Features. The lift shall consist of a 12-square-foot horizontal platform enclosed by a combination of panels, railings, doors, a lifting mechanism to raise and lower the platform, and suitable control and safety devices.

E. Vertical Wheelchair Lift Performance. Maximum rise shall not exceed 6 feet. Capacity shall be 450 pounds. Maximum speed shall be 30 fpm.

F. Inclined Wheelchair Lift Performance. Maximum angles shall be 45 degrees. Maximum travel shall not exceed 35 feet (measured on the incline), and not more than two consecutive floors. Capacity shall be 450 pounds.

G. Restrictions. Lifts shall not be installed where lobby areas and inclined areas are greatly reduced or where they present a hazard. Inclined lifts shall not be installed on stairs with low headroom clearance. When inclined lifts are installed on egress stairs, lifts shall not encroach on the required units of egress.

8.3.2 Exterior Power Platforms

A. Codes and Standards. Exterior power platforms shall conform to the latest edition of the American Society of Mechanical Engineers (ASME) Safety Requirements for Powered Platforms and Traveling Ladders and Gantries for Building Maintenance, A120.1.

B Planning. Exterior power platforms, for window washing and for other maintenance, shall be determined on an individual project basis.

C Architectural and Structural Limitations. The provisions of an acceptable powered platform may restrict, to a minor degree, the freedom that would otherwise be available in the architectural and structural design of the building.

D Safety Requirements. Each powered platform installation shall be designed, installed, inspected, and tested in accordance with the latest edition of the American National Standards Safety Requirements for Powered Platforms for Exterior Building Maintenance.

E Mechanical Design Features. Powered platforms shall be designed to incorporate the following basic safety and operating features:

1) Roof cars shall be gravity stable, considering both overturning moment and wind loading, with an adequate safety factor. This requirement dictates a lightweight working platform and a relatively heavy roof car. Tiedowns or safety brackets on the roof car shall be considered only as an additional safeguard to prevent overturning. Roof car track and wheels shall be designed to minimize noise which might be annoying to occupants of the building.

2) Working platforms shall be supported by four wire ropes, equipped with approved means to detect and prevent over or under tensions in any rope, attached at or near each end of the platform. Platform working area shall be clear. Support ropes shall be located in front of surfaces to be washed.

3) Working platforms shall be steadied against the building face to prevent swaying in gusts of wind, or when workmen press against the building in the process of washing windows or making other repairs. Fixed guides are required in the face of the exterior of buildings, 130 feet and over in height, to accomplish this purpose. The working platform shall travel only in the level position.

4) The equipment shall be operable by a single worker. It shall not require any standby worker on the roof car, or elsewhere, while in use. Sometimes two workers may be used on the working platform to perform the washing or maintenance operation.

5) Operation and control provisions shall be as nearly fail-safe as practical. Protective devices such as limit switches shall be provided to minimize the possibility of malfunctions or improper operation. Operating buttons shall

be of the deadman type.

6) The main power supply outlets for the power platform located on the roof shall be of a type to prevent hazards to workers during all weather conditions.

7) Telephone connections shall be provided for help in the event of power failure, control failure, or similar emergencies. Rescue provisions shall be included to permit manual lowering of the platform or to facilitate removal of workers trapped on a platform.

F. Coordination. The designer shall coordinate to ensure that the architectural and structural design will accommodate the different manufacturers' equipment. Loads imposed by the power-operated platform on the roof structure, parapet, mullions, exterior walls, or vertical guides shall be considered in the design. A garage shall be provided on the roof to protect the equipment during periods of inclement weather. This garage will improve the appearance of the building when the power-operated platform is not in use, and will facilitate maintenance of the equipment.

9. BIOHAZARD CONTAINMENT DESIGN

9.1 GENERAL

9.1.1 Scope

This chapter provides general guidance for the design of facilities which support research activities with biohazardous materials. Its objective is to provide, by incorporating special equipment and features in the design of the facility, the best possible physical containment of these agents. Such a facility is called a "biocontainment" facility.

The entire physical containment system for such a facility supporting agricultural research is unique in that it must function to prevent the spread of infectious agents to the environment, to other animals or plants, and between research experiments, as well as to humans.

Each biocontainment facility is unique in design and function, and only clear, close, and constant communication between the A-E and the responsible ARS officials during the predesign and design phases will ensure the development of plans and specifications that can guide the contractor in the construction, testing and certification of an effective biocontainment facility.

9.1.2 Objectives

The functional objectives of the biological containment facility are the: 1) protection of employees, contractors, and visitors from injury, illness, or accident as a result of work activities; 2) protection of experimental studies by preventing the spread of disease agents from one biocontainment area to another; and 3) protection of the environment by preventing the escape of disease agents causing any of the diseases studied at the facility.

9.1.3 Basic Requirements

The design of the biocontainment facility shall comply with all codes and standards applicable to the project, and described in other chapters of this Manual.

All ARS facilities are subject to Section 619 of Title 40 of the Code of Federal Regulations, which requires all Federal facilities to comply, to the maximum extent feasible, with all national codes and standards. If, in the course of developing the design documents for the construction or renovation of a biocontainment facility, the

A-E becomes aware of a required element of the design in apparent conflict with national codes and standards, or with any particular requirement of this or any other chapter of this manual, the A-E shall submit, in writing, a request for a waiver to the Contracting Officer (CO). The CO will forward the request to the responsible ARS official for action. The waiver need not be extensive in nature, but it must clearly describe in detail the apparent conflict and the absolute need for the waiver.

9.1.4 Biohazard

“Biohazard” is a contraction of the words “biological” and ”hazard.” A biohazard is defined as an infectious agent, or a part thereof, presenting a real or potential risk to humans, animals, or plants, either directly through infection, or indirectly through disruption of the environment. In certain regulations these are referred to as infectious substances.

9.1.5 Barriers

(It must always be remembered that physical barriers do not substitute for good laboratory practice, as described in such sources as the latest edition of the CDC/NIH publication “Biosafety in Microbiological and Biomedical Laboratories.”)

To establish multiple protective layers (layered approach) to contain biohazardous materials, the facility shall be designed and constructed with three levels of barriers to meet the above objectives:

A. Primary Barriers. Usually these are specialized items of equipment designed and specified for capture or containment of biological agents. Biological Safety Cabinets and animal cage dump stations are examples of larger primary barriers. Trunnion centrifuge cups, bioaerosol centrifuges, aerosol containing blenders, high speed mixers and related devices are examples of smaller primary barriers.

B.. Secondary Barriers. These are facility related design features and operational practices that protect the environment external to the laboratory from exposure to biohazardous materials (from one interior area to another, or from the interior of the facility to the outside environment). Examples of secondary barriers include work areas that are separate from public areas, decontamination and hand washing facilities, special ventilation systems, airlocks, directional airflow through the use of air pressure differentials, double door autoclaves opening to the exterior, air gasketed doors (interior and exterior) and administrative controls such as risk assessment. All personnel practices that are involved in maintaining these systems, or in minimizing personal contamination and the spread of infectious microorganisms, are also an integral part of the secondary barrier system, along with personnel practices and good laboratory housekeeping.

C. Tertiary Barriers. These are systems that are designed and maintained to minimize or control access to contaminated areas. These include physical barriers such as the building proper, perimeter fencing, remote controls and monitoring devices. Administrative controls may also include security personnel, controlled access for authorized personnel and for visitors and non-security cleared personnel to be escorted while in a restricted area.

In certain facilities, it might be desirable for some spaces surrounding the containment area to act as tertiary barriers. Examples could be: mechanical and utility spaces; interstitial spaces housing ventilation ductwork and utility piping; and attics and double-walled construction surrounding the primary containment zone. No research work or housing of animals takes place in these areas, so they would not be expected to be contaminated. These areas are not considered containment spaces but, if ventilated, are referred to as “containable” spaces. These areas are kept under negative pressure and their exhaust systems are equipped with HEPA filters. Penetrations into these areas were sealed at the time of construction to allow decontamination, but these areas are not required to pass a pressure decay test. Persons leaving these areas are not usually required to shower before leaving the facility.

9.1.6 Additional Reading

A. Animal and Plant Health Inspection Service (APHIS)

1) “Quarantine Facility Guidelines for Microorganisms”

2) “Containment Guidelines for Non-indigenous, Phytophagous Arthropods and Their Parasitoids and Predators”

3) “Quarantine Facility Guidelines for the Receipt and Containment of Nonindigenous Arthropod Herbivores, Parasitoids and Predators”

B. Center for Disease Control and Prevention/ National Institutes of Health (CDC/NIH)

1) “Biosafety in Microbiological and Biomedical Laboratories,” 4th Edition

2) “The Guide for the Care and Use of Laboratory Animals” (NIH)

C. American Association for the Accreditation of Laboratory Animal Care International (AAALAC). See the web site http://www.aaalac.org/ .See the web site http://www.aaalac.org/ .

9.2 HAZARD CLASSIFICATION AND CHOICE OF CONTAINMENT

9.2.1 General

In consultation with the location scientific programs and administrative representatives, the ARS Research Programs Safety Officer (RPSO) will determine the appropriate biosafety level (see the next paragraph) for each new or renovated space in the Program of Requirements developed for the facility.

9.2.2 Biosafety Levels

Five biosafety levels are described below. Four are recognized universally (see the latest edition of the CDC/NIH publication “Biosafety in Microbiological and Biomedical Laboratories”), and one (BSL-3Ag) is unique to ARS. These levels consist of combinations of laboratory practices and techniques, safety equipment, and facility design features appropriate for the dangers posed by the biohazardous materials, and by the procedures to be performed with these agents. These five biosafety level designations are applicable to all types of containment spaces, including laboratories, animal rooms, corridors, greenhouses, necropsy rooms, insect rearing facilities, carcass disposal facilities, etc.

The five biosafety levels, and the general types of biohazardous materials they are meant to contain, are:

A. <u>Biosafety Level 1 (BSL-1)</u>. Used with agents of no known or minimal potential hazard to facility personnel, animals or the environment. They present no potential economic loss to the agricultural industries.

B. <u>Biosafety Level 2 (BSL-2)</u>. Used with agents of moderate potential hazard to personnel, animals, and the environment, with minimal economic loss to the animal industries. Most research and diagnostics laboratories are at this level. It is the policy of ARS that any laboratory where research is being conducted on infectious agents will be designed, built and operated at a BSL-2 standard at a minimum.

C. <u>Biosafety Level 3 (BSL-3)</u>. Used with agents which may be indigenous or exotic to the United States that can be contracted by the respiratory route, and may cause serious or lethal diseases to man, animals, or cause moderate economic loss to the animal industries.

D. Biosafety Level 3 Agriculture (BSL-3Ag). Used with pathogens that present a risk of causing infections of animals and plants and causing a great economic harm. (Foot and Mouth Disease is the premier example.)

E. Biosafety Level 4 (BSL-4). Used with highly lethal exotic agents which pose a high individual risk of life threatening disease to man. Certain of these viruses also infect food animals and have the potential to cause severe economic loss to animal industries.

In certain instances, the RPSO may require enhancements to the standard design features of a given BSL classification (e.g., under certain conditions, the RPSO may require treatment of biowaste from a BSL-2 facility). Some research work, involving transgenic materials, non-indigenous species, or other exotic organisms, may require that the standard BSL-2 facility be enhanced. These facilities may require design review and certification by APHIS. Any additional requirements will be identified by the RPSO during the programming phase of the project.

9.3 PRIMARY BARRIERS (CONTAINMENT EQUIPMENT)

9.3.1 General

Biological safety cabinets (BSCs) are the principal primary barriers used to provide physical containment. (Other primary barriers are enclosed containers, safety centrifuge cups, and personal protective equipment such as gloves, gowns, respirators, and face shields.) BSCs are used to prevent the escape of aerosols into the laboratory or outside environment. Certain cabinets can also protect experimental work from airborne contamination. The selection of the appropriate BSC is based on the potential hazard of the agent used in the experiment, the potential of the laboratory operation to produce aerosols, the potential use of certain chemicals, and the need to protect the experiment from airborne contamination. The types, numbers and locations of BSCs to be used in the facility will be determined by the ARS Research Program Representative (RPR), and confirmed by the ARS RPSO in the project's Program of Requirements.

Complete information on Biological Safety Cabinets can be found in the CDC/NIH publication "Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets," 2nd Edition, September 2000, available from the U.S. Government Printing Office, Washington, D. C. 20402.

When large animals cannot be housed in ventilated containment cages/units, certain features of the animal room (HEPA exhaust filters and the sealed and pressure-tested room surfaces) act as the primary barriers.

9.4 SECONDARY BARRIERS (FACILITY DESIGN FEATURES)

9.4.1 General

Special containment features, when incorporated in the design of biological research facilities, act as secondary barriers against the possible contamination of the immediate and general environment beyond the containment space. The following paragraphs describe the design features for the five levels of containment recognized by ARS.

Because of the complexity and expense of the containment systems, a biological research facility is divided into research (containment) zones and support (non-containment) zones. The non-containment zones support those research operations that do not involve the manipulation of extremely biohazardous materials. These zones include: entrances; offices; support rooms for the preparation of materials; holding rooms for "clean" animals; spaces for washing already sterilized glassware, media and equipment; and mechanical and electrical rooms that hold as much of the engineering support equipment that can be located outside of the containment areas as possible. These non-containment zones are usually on the perimeter of the spaces that make up the containment zones. They provide a buffer zone around the containment facilities, and are the areas from which personnel and materials enter and leave the containment facilities. Depending upon the architectural layout of the facility, the A-E shall consider using ”containable” spaces surrounding the containment areas.

9.4.2 Biosafety Levels 1 and 2 (BSL-1 and BSL-2)

A. In general, a BSL-1 facility represents a basic level of containment that relies on standard microbiological practices with no special or secondary barriers recommended, other than a sink for hand washing, and self closing and lockable doors. The facility must be insect and rodent proof.

B. BSL-2 facilities, in general, support research with agents that, as aerosols, could increase the risk of infection, and must have available primary containment such as BSCs, safety centrifuge cups and/or personal protection equipment. The BSL-2 facility should include the secondary barriers of a foot, elbow or automatically operated hand washing station located near the exit of each functional area within containment, and an autoclave, or other appropriate type of biohazardous waste treatment, to process infectious wastes. With appropriate procedural controls, non-infectious wastes from a BSL-2 facility could be decontaminated at a remote site within the same building.

C. If laboratory animals are used, a BSL-2 animal facility must have appropriate cage storage areas and appropriate means of cleaning the cages or caging systems. Any mechanical cage washer should be capable of producing a final rinse temperature of at least 180 degrees F, but should also be able to operate at lower temperatures to save energy and to prevent damage to some types of plastic cages.

D. The BSL-1 and BSL-2 facilities should provide an internal environment which is easily cleanable. The walls and floors should be surfaced with or be constructed of materials which can withstand harsh detergents, disinfectants and decontaminating agents. Horizontal surfaces and open storage cabinets which may collect dust should be minimized, and suspended fixtures, such as fluorescent lighting and exposed service piping, should be accessible for cleaning. Bench tops should be impervious to liquids and resistant to acids, alkalis, organic solvents, and moderate heat.

E. The facility furniture should be sturdy and readily cleanable. Voids in furniture groupings should be accessible for cleaning. The use of carpets, rugs, and cloth-covered, porous furniture is inappropriate in a biocontainment facility. Open shelving should be avoided; closed cabinets minimize dust buildup on their shelves and contain splashes of liquids.

F. Although the primary consideration in the arrangement of the furnishings is their suitability for the research program, floor plans should include environmental control and safety considerations. Work spaces should be planned to be out of through traffic areas. If BSCs are provided, they shall be located deep in the laboratory, preferably at "dead ends," where foot traffic that could disturb the laminar flow of air in the BSCs would be minimized. They shall also be located away from supply air outlets. The floor plans should separate clean and contaminated operations. Extraneous traffic should be minimized. Although formal offices should not be included in the laboratory, an area should be provided to allow researchers to record notes, possibly at a computer workstation with a laptop, or to fax materials. Doors should be equipped with self-closing devices to reduce and control the entry of non-facility personnel, and with locks or key card access.

G. BSL-1 and BSL-2 laboratories shall be ventilated as required by Chapters 5 and

7 of ARS Manual 242.1, with negative (usually) pressurization relative to the surrounding spaces, exhaust air being ducted, and recirculation of laboratory air being prohibited. Operable windows are not allowed in order to preserve the specified and established air balance.

H. BSL-1 and BSL-2 animal facilities shall be ventilated as required by Chapter 10 of the ARS Manual 242.1 and the latest edition of the "Guide for the Care and Use of Laboratory Animals." Again, the animal facility rooms shall be maintained at negative pressure relative to the surrounding areas, the exhaust air cannot be recirculated, and the direction of the airflow is inward.

I. For animal facilities, all wall, floor and bench surfaces shall be smooth surfaced, and all penetrations will be sealed to control vermin.

J. For a summary of the general containment guidelines for BSL-1 and BSL-2 facilities, see Table 9-1.

9.4.3 Biosafety Level 3 (BSL-3)

A. A BSL-3 facility is designed to support research activities with serious or potentially lethal biohazardous materials or infectious substances.

B. All BSL-3 facilities shall have the secondary containment features listed in sections 9.4.2(A) through 9.4.2(F) above.

C. The unique features which distinguish the BSL-3 facility from the BSL-1 and BSL-2 facilities are the provisions for: access control, safety equipment, a specialized ventilation system, and sealed finishes and penetrations.

1) For access control, the BSL-3 laboratory or facility should be completely separated from areas that are open to the public, and from corridors used by laboratory personnel who do not work in the BSL-3 facility. The change room and shower facility arrangement provides the greatest access control of any of the examples and is strongly recommended for laboratories; this arrangement is required for animal facilities at this level of containment. All facility doors must be self-closing.

2) <u>Safety equipment includes biological safety cabinets and autoclaves</u>.

a) Each BSL-3 laboratory or module in a BSL-3 facility should be equipped with an appropriate Class II or III BSC to contain certain procedures when moderately infectious agents are being studied. Potentially hazardous procedures shall be confined to ventilated safety cabinets. Protective cabinets shall be used whenever biohazardous materials are handled outside fully contained vessels.

b) An autoclave for the decontamination of facility wastes must be located within the BSL-3 space. A double door (having two doors in series) and interlocked autoclave with access outside the laboratory or facility provides an excellent method for providing clean/contaminated materials flow. With appropriate procedural controls, an autoclave may be located outside of the BSL-3 laboratory, providing it is located within the same building.

3) A specialized ventilation system to control air movement is a requirement for a BSL-3 facility. A ducted exhaust air ventilation system must be provided. The exhaust air may not be recirculated to any other area of the building. In general, exhaust air may not require filtration or other treatments, but special site requirements, or certain activities with, or uses of, hazardous agents may dictate the use of HEPA filtration. Air from the containment space is to be discharged to the outside so that it either clears occupied buildings and air intakes (this is usually done by locating the exhaust stacks on the roof and discharging upward at a velocity greater than 3,000 fpm). The laboratory staff must ensure that the flow of air is always into the containment space. A visual monitoring device should be provided at the space's entry to confirm the inward direction of the airflow. Supply air systems must be designed to prevent the positive air pressurization of the space and the reversal of airflow from the containment areas to the non-containment areas of the building. A device for monitoring airflow, and possibly an alarm, should be provided to alert facility personnel to an air pressure problem.

4) Balance of the supply air and exhaust air should provide a directional airflow with the air drawn into the facility through the entry area. Recommendations to create this infiltration include: a 15 percent airflow differential between exhaust and supply, or sufficient exhaust to create a 0.05" water column differential between the containment area and the access area. With either method, it is recommended that the infiltration of air into the containment area be at least 50 CFM per doorway, at all times. Within the BSL-3 facility, the supply and exhaust systems should be distributed and balanced so that the flow of air between functional spaces is always in the direction of areas of increasing biological hazard potential.

At this level of containment, electronic direct digital controls (DDC) should always be used to manage the ventilation systems unless their use would be impractical due to small project size, difficulty of operation and/or maintenance due to the facility's location, or some other factor. In addition, a Building Automation System (BAS), also known as a Facility Management System, which can manage energy, and control signaling functions such as security, fire safety, alarms of all types, communications, and data logging, and which can also provide graphical displays and generate reports, should be provided, unless its use would be impractical for reasons like those cited for the DDC system.

5) In rare circumstances, and after having obtained a written waiver from the RPSO, recirculation of the air within an individual containment space is permitted, if the air is HEPA filtered.

6) The BSL-3 space must be constructed with sealed finishes and penetrations and sealable doors to permit gaseous biological decontamination. All furnishings and equipment must be able to be decontaminated by some proven means, or be able to be disposed of. All utility pipe and duct penetrations, electrical conduits, utility access and other passages through floors, walls and ceilings must be sealed to assure isolation of the space environment. The types of anchors for utility services and their means of attachment to walls, floors, ceilings, etc., shall be carefully selected and detailed to result in a sealed surface. Floors must be impervious to liquids, with sealed seams, resistant to chemicals, and present a surface that will minimize slipping hazards. Heat seamed vinyl flooring and poured epoxy flooring are acceptable finishes. Walls of laboratories should be constructed of concrete block, cement board or plastic construction. Walls of animal rooms, animal corridors and necropsy areas shall be of cast-in-place concrete. All walls must be finished with enamel, epoxy, acrylic latex or other sealing compound that will permit frequent decontamination and cleaning. All joints and seams in the walls must be sealed. This feature will control air movement and stop entry of insects and other vermin. Ceilings should be constructed, sealed and finished in the same general manner as walls. Depending on the particular design, either the ceiling itself, or the structure above the ceiling, could form part of the biocontainment barrier. If the structure itself forms part of the biocontainment barrier, standard ceiling materials, either easily cleanable or easily disposable, can be used. If the structure itself does not form part of the biocontainment barrier, the use of suspended tile ceilings will be allowed only after a written waiver is received from the RPSO, because of leakage, dirt and insect control.

Light fixtures must be recessed and sealed to minimize dirt deposits. Ceiling diffusers should be sealed to control air leaks from the containment space.

7) Containment greenhouses must be glazed with double-paned laminated glass. Containment greenhouse design requirements are discussed further in the referenced APHIS documents.

8) Any windows in a BSL-3 facility must be inoperable and sealed in the shut position. All facility doors must be self-closing.

9) Provisions for dealing with scheduled maintenance or equipment repair problems must be incorporated into BSL-3 facility design. The design should minimize the need for non-research personnel to enter the containment space to perform maintenance functions. Where possible, compressor monitors or gas supplies which can be isolated should be made accessible from outside the containment space. Compressed gas cylinders supplying carbon dioxide, nitrogen and other gases should be stored outside the containment space, and manifold piping should be used to provide the gases inside the area. Central vacuum systems are not recommended, because of the potential problems of radiological and biological contamination of their piping, and the potential for exhaust air contamination. Small individual vacuum pumps equipped with in-line HEPA filters shall be used within the containment space.

10) The HEPA filtered exhaust air from Class II, Type A ("Laminar Flow") BSC’s may either be returned to the laboratory environment or discharged to the outdoors. Class I, Class II, Types B1 and B2 (the new 100 percent exhaust "Laminar Flow" cabinet), and Class III cabinets usually require external exhaust fans and may be directly connected to a building’s exhaust system. The treated exhaust from these BSCs must be discharged outdoors. Room supply and exhaust systems, and the exhaust systems for these cabinets, must be designed and operated in a manner that does not interfere with the air balance of the rooms and the BSCs. The cabinets must be located so that they can easily be maintained, decontaminated and certified.

D. For a summary of the general containment guidelines for a BSL-3 facility, see Table 9-1.

9.4.4 Biosafety Level 3 Agriculture (BSL-3Ag)

A. In ARS, special features are required when research involves certain biological agents in large animal species. To support such research, ARS has developed a special facility designed, constructed and operated at a unique containment level called Biosafety Level 3 Agriculture (BSL-3Ag). Using the containment features of the standard BSL-3 facility as a starting point, BSL-3Ag facilities are specifically designed to protect the environment by including almost all of the features ordinarily used for BSL-4 facilities as enhancements. All BSL-3Ag containment spaces must be designed, constructed and certified as primary containment barriers.

The BSL-3Ag facility can be a separate building, but, more often, it is an isolated zone contained within a facility operating at a lower biosafety level, usually a BSL-3. This isolated zone has strictly controlled access, and special physical security measures, and functions on the “box within a box” principle.

B. All BSL-3Ag facilities require the features listed in sections 9.4.2(A) through 9.4.2(F), and sections 9.4.3(C)(1) through 9.4.3(C)(3), and 9.4.3(C)(8).

C. In addition, the mandatory special features for a BSL-3Ag facility include:

1) Personnel change and shower rooms that provide for the separation of street clothing from laboratory clothing and that control access to the containment spaces. The facility is arranged so that personnel ingress and egress are only through a series of rooms (usually one series for men and one for women) consisting of: a ventilated vestibule with compressible gaskets on the two doors, a “clean” change room outside containment, a shower room at the non-containment/containment boundary, and a “dirty” change room within containment. Complete laboratory clothing (including undergarments, pants and shirts or jump suits, and shoes and gloves) is provided in the “dirty” change room, and put on by personnel before entering the research areas. In some facilities, complete laboratory clothing and personal protective equipment (PPE) are provided in the “clean” change room, where they can be stored and stowed for use without entry into containment.

   In general, when leaving a BSL-3Ag laboratory, where all open handling of infectious materials is done in BSCs or other physical containment equipment, personnel need not take a shower to go to any other containment space within the facility, and would be required to take only the access control shower to leave the facility.

   However, when leaving a BSL-3Ag large animal space (an animal room, necropsy room, carcass disposal area, contaminated corridor, etc.) that acts as the primary barrier and that contains large volumes of aerosols holding highly infectious agents, personnel usually would be required to remove their “dirty” lab clothing, take a shower, and put on ”clean” lab clothing immediately after leaving this high risk BSL-3Ag animal space and before going to any other part containment space within facility. When leaving the facility, these personnel would take another shower at the access control shower and put on their street clothing.

It is very important for the A-E to realize that the location, size and number of change rooms and showers within a facility need to be programmed very carefully with the scientists and staff at the location due to the unique circumstances at each research center.

Soiled clothing worn in a BSL-3Ag space is autoclaved before being laundered. Personnel moving from one space within containment to another will follow the practices and procedures described in the biosafety manual specifically developed for the particular facility and adopted by the laboratory director.

2) Access doors to these facilities are self closing and lockable. Emergency exit doors are provided, but are locked on the outside against unauthorized use. The A-E shall consider the practicality of providing vestibules at emergency exits.

3) Supplies, materials and equipment enter the BSL-3Ag space only through an airlock, fumigation chamber or an interlocked and double-door autoclave.

4) Double-door autoclaves engineered with bioseals are provided to decontaminate laboratory waste passing out of the containment area. The double doors of the autoclaves must be interlocked so that the outer door can be opened only after the completion of the sterilizing cycle, and to prevent the simultaneous opening of both doors. All double door autoclaves are situated through an exterior wall of the containment area, with the autoclave unit forming an air tight seal with the barrier wall and the bulk of the autoclave situated outside the containment space so that autoclave maintenance can be performed conveniently. A gas sterilizer, a pass-through liquid dunk tank, or a cold gas decontamination chamber must be provided for the safe removal of materials and equipment that are steam or heat sensitive. Disposable materials must be autoclaved before leaving the BSL-3Ag space, and then incinerated.

5) Dedicated, single pass, directional, and pressure gradient ventilation systems must be used. All BSL-3Ag facilities have independent air supply and exhaust systems. The systems are operated to provide directional airflow and a negative air pressure within the containment space. The directional airflow within the containment spaces moves from areas of least hazard potential toward areas of greatest hazard potential. A visible means of displaying pressure differentials is provided. They can be seen inside and outside of the containment space, and sound an alarm when the preset pressure differential is not maintained. The air supply and exhaust systems must be interlocked to prevent reversal of the directional airflow and the containment spaces becoming positively pressurized, in the event of an exhaust system failure.

6) Supply and exhaust air to and from the containment space is HEPA filtered, with special electrical interlocks to prevent positive pressurization during electrical or mechanical breakdowns. The exhaust air is discharged in such a manner that it cannot be drawn into outside air intake systems. The HEPA filters are outside of containment but are located as near as possible to the containment space to minimize the length of potentially contaminated air ducts. The HEPA filter housings are fabricated to permit the scan testing of the filters in place after installation, and to permit filter decontamination before removal. Backup HEPA filter units are strongly recommended to allow filter changes without disrupting research. (The most severe requirements for these modern, high level biocontainment facilities include HEPA filters arranged both in series and in parallel on the exhaust side, and series HEPA filters on the supply side of the HVAC systems serving “high risk” areas where large amounts of aerosols containing BSL-3Ag agents could be expected [e.g., large animal rooms, contaminated corridors, necropsy areas, carcass disposal facilities, etc.])

   For these high risk areas, redundant supply fans are recommended, and redundant exhaust fans are required. The supply and exhaust air systems should be filtered with 80-90 percent efficiency filters to prolong the life of the supply and exhaust HEPA filters. Air handling systems must provide 100 percent outside conditioned air to the containment spaces.

7) Liquid effluents from BSL-3Ag areas must be collected and decontaminated in a central liquid waste sterilization system before disposal into the sanitary sewers. Equipment must be provided to process, heat and hold the contaminated liquid effluents to temperatures, pressures and times sufficient to inactivate all biohazardous materials that

reasonably can be expected to be studied at the facility in the future. The system may need to operate at a wide range of temperatures and holding times to process the facility's effluents economically and efficiently. Double containment piping systems with leak alarms and annular space decontaminating capability should be considered for these wastes. Effluents from laboratory sinks, cabinets, floors and autoclave chambers are sterilized by heat treatment. Under certain conditions, liquid wastes from shower rooms and toilets may be decontaminated by chemicals. Facilities must be constructed with appropriate basements or piping tunnels to allow for inspection of plumbing systems.

8) Each BSL-3Ag containment space shall have its interior surfaces (walls, floors, and ceilings) and penetrations sealed to create a functional area capable of passing a pressure decay test with a leak rate established by the ARS RPSO. This requirement includes all interior surfaces of all BSL-3Ag spaces, not just the surfaces making up the external containment boundary. All walls are constructed slab to slab, and all penetrations, of whatever type, are sealed airtight to prevent escape of contained agents and to allow gaseous fumigation biological decontamination. This prevents cross contamination between individual BSL-3Ag spaces and allows gaseous fumigation in one space without affecting other BSL-3Ag spaces. Exterior windows and vision panels, if required, are breakage-resistant and sealed.

   Greenhouses constructed to meet the BSL-3Ag containment level will undergo the following tests, or the latest subsequent standards: (a) an air infiltration test conducted according to ASTM E 283-91; (b) a static pressure water resistance test conducted according to ASTM E 331-93; and (c) a dynamic pressure water resistance test conducted according to AAMA 501.1-94.

9) All ductwork serving BSL-3Ag spaces shall be airtight and pressure tested (see Appendix 9B for testing and certification details).

10) The hinges and latch/knob areas of all passage doors shall be sealed to meet pressure decay testing requirements.

11) All airlock doors shall have air inflated or compressible gaskets. The compressed air lines to the air inflated gaskets shall be provided with HEPA filters and check valves.

12) Restraining devices shall be provided in large animal rooms.

13) Necropsy rooms shall be sized and equipped to accommodate large farm animals.

14) Pathological incinerators, or other approved means, must be provided for the safe disposal of the large carcasses of infected animals. Redundancy and the use of multiple technologies need to be considered and evaluated.

15) HEPA filters must be installed on all atmospheric vents serving plumbing traps, as near as possible to the point of use, or to the service cock, of central or local vacuum systems, and on the return lines of compressed air systems. All HEPA filters are installed to allow in-place decontamination and replacement. All traps are filled with liquid disinfectant.

16) Biological Safety Cabinets must be provided and must be installed where their operations are not adversely affected by air circulation and foot traffic. Class II BSCs use HEPA filters to treat their supply and exhaust air. The exhaust from most Class II cabinets must be connected to the building's exhaust system. Supply air to a Class III cabinet is HEPA filtered, and the exhaust air must be double HEPA filtered (through a cabinet HEPA and then through a HEPA in a dedicated building exhaust system), before being discharged to the atmosphere.

    A BSL-3Ag facility will be provided only at those locations where the research mission requires this special type of facility; that is, where the facility barriers, usually considered secondary barriers, now act as primary barriers. Examples are sealed interior surfaces (walls, ceilings and floors of each containment space), ventilation systems, pathological incinerators, effluent sterilization systems, HEPA filters, etc. This requirement exists, in most cases, to contain biologically hazardous aerosols.

    The BSL-3Ag facility must undergo special testing and certification procedures.

    See Appendix B, "Testing and Certification Requirements for Critical Components of the Biological Containment System," at the end of this chapter, and the Design Details Manual.

D. For a summary of the general containment guidelines for a BSL-3Ag facility, see Table 9-1.

9.4.5 Biosafety Level 4 (BSL-4)

A. A BSL-4 facility is designed to support the safe conduct of research involving biological agents that are extremely hazardous to individuals, or that may cause serious epidemic disease. Some of these viruses are zoonotic and infect large food animals and may have a severe economic impact.

B. All BSL-4 facilities shall have the secondary containment features listed in sections 9.4.2(A) through 9.4.2(F), sections 9.4.3(C)(1) through 9.4.3(C)(8), and sections 9.4.4(C)(1) through 9.4.4(C)16). Additional features are discussed below.

C. There are two types of BSL-4 laboratories, the Cabinet Laboratory and the Suit Laboratory.

D. Additional secondary features for a BSL-4 facility are as follows:

1) In the Cabinet Laboratory, primary containment of the biohazardous materials is provided by Class III Biosafety Cabinets. These are totally enclosed and ventilated cabinets of gas-tight construction. Operations within these cabinets are conducted through attached rubber gloves. When in use, the cabinets are maintained under a negative pressure of 0.5 to 0.75 inches of water (125 Pa to 188 Pa). The exhaust system for the cabinet must be a dedicated system.

2) Class III cabinets are designed generally as a system of interconnected cabinets which contain sufficient space for all research procedures. Refrigerators, incubators, centrifuges, animal cages and other equipment are housed in the cabinets so that the research can be performed without removing materials from the cabinet system. Double door autoclaves and chemical dunk tanks are installed as integral parts of the system, to allow the safe introduction and removal of supplies and equipment.

3) Usually when animals, especially large animals, are to be used, a Suit Laboratory is preferred. These laboratories protect the user from the potentially contaminated environment by a one-piece, positively pressurized suit that is ventilated by a life support system. Air supplied to the suit is HEPA filtered. The suit’s redundant air supply system is provided with alarms and is further provided with an emergency backup air tank. In these suit areas (laboratories with Class II BSCs, large animal rooms, animal corridors, necropsy facilities, etc.), the internal shell of the space must be airtight, and the space must be able to pass a pressure decay

test as required by the ARS RPSO. Redundant supply fans are recommended; redundant exhaust fans are required. Emergency lighting and communications are provided in these suit areas. Personnel can enter and leave these suit areas only through a ventilated airlock containing a chemical shower for suit decontamination. The airlock is created by a pair of airtight doors with air-inflatable gaskets. These doors are interlocked so that only one door can be opened at any time. All spaces are designed to be free of sharp edges or protrusions that could tear the suits. Glassware is prohibited and unbreakable plastics substituted.

4) The chemical shower is used to decontaminate the positively pressurized suit before its removal. The exhaust air from this chemical shower room is filtered through two HEPA filters in series. The negative pressure in this shower room is greater than in any adjacent area. “Clean” researchers leaving a BSL-4 Cabinet Laboratory and the facility will go through the “access” shower only. Researchers leaving a BSL-4 Suit Laboratory and the facility would take a chemical shower to decontaminate the suit, and then go through the “access” shower to take a personal shower before dressing in street clothing.

5) In general, laboratory animals infected with BSL-4 agents must be housed with individual caging dependant on the species. Farm animals must be housed and restrained in a way designed to protect the physical safety of workers in suits. When infected animals are housed in a partial containment system (e.g., open cages placed in ventilated enclosures; cages with solid walls and bottoms, covered with filter bonnets and opened in laminar flow hoods; or other equivalent primary containment systems), then the room itself acts as the primary barrier, and all personnel would be required to wear the one-piece, positive pressure suit.

6) Large animals infected with BSL-4 agents must be housed in BSL-4 animal rooms acting as primary barriers. These rooms must have an adjacent vestibule having a chemical shower to allow the area to become a true ventilated suit area. All personnel would be required to wear the one-piece positively pressurized suit. The large animal facility must have an integral necropsy room equipped to handle the largest animal housed in the facility, and an animal carcass disposal system that can inactivate all the pathogens being studied.

E. The BSL-4 Facility must undergo special testing and certification procedures. See Appendix 9B, “Testing and Certification Requirements for Critical Components of the Biological Containment System,” at the end of this chapter, and the separate Design Details Manual.

F. For a summary of the general containment guidelines for a BSL-4 Facility, see Table 9-1.

Table 9 -1
General Containment Guidelines

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
Facility Features:					
1. Personnel Entry/Exit through Clothing Change & Shower Rooms	n/a	n/a	recommended	required	required
2. Materials, Supplies, & Equipment enter/leave through Double-Door Autoclave, Fumigation Chamber, or Airlock	n/a	n/a	required	required	required
3. Work Conducted in Primary Containment Equipment.	open bench tops	as required	required	required (If the space is a lab.)	required
4. Hand Washing Station *****(Foot, elbow or automatically operated)	required	recommended*	required*****	required*	required* (not where a suit would be worn)
5. Laboratory and Animal Room Wastes from the Containment Area Decontaminated or Sterilized	n/a	recommended	recommended	required	required
6. Lab Clothing Decontaminated Before Being Washed	n/a	n/a; to be disposed of in the lab or washed by the facility	required	required	required
7. Animal Cages Autoclaved or Thoroughly Decontaminated Before	cages washed, then rinsed at 180 degrees.	cages washed, then rinsed at 180 degrees.	cages washed, then rinsed at 180 degrees.	required	required

Table 9 -1
General Containment Guidelines

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
Cleaning					
8. Appropriate Cautionary Signs	n/a	required	required	required	required
9. Separate Building or Isolated Zone Within a Building	n/a	n/a	required	required	required
10. BSC or other Appropriate Personal Protective or Physical Containment Devices	n/a	Class I or Class II BSC	Class II or Class III BSC	Class II or Class III BSC	Class III <u>or</u> Class I or II BSC with ventilated suit
11. Suit Room	n/a	n/a	n/a	n/a	AS REQUIRED
12. Steam and/or Ethylene Oxide Sterilizers:	recommended	required	required **(**integral**,** double door**)**	integral, double-door	integral, double-door
13. Liquid Effluent (Bio-Waste) Treatment System	n/a	not required	required	required	required
14. Personnel Change Room	n/a	n/a	recommended for laboratories; required for animal facilities.	required	required
15. Shower Available Within Facility	n/a	n/a	recommended for laboratories; required for animal facilities.	required	required
16. Lab Contiguous with Shower	n/a	n/a	n/a	as required for lab; required for “high risk” areas	required
17. Work Surfaces: Bench Tops Impervious	required	required	required	required	seamless required

Table 9 -1
General Containment Guidelines

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
to Water, Resistant to Acids, Alkalis, Organic Solvents and Moderate Heat.					
18. Interior Surfaces of Walls, Floors, and Ceilings: Monolithic, Resistant to Liquids and Chemicals, all Penetrations Sealed. Any Drains in the Floors Contain Traps Filled with Chemical Disinfectant	n/a	walls, floors, and ceilings are monolithic, resistant to liquids and chemicals.	required	required	required
19. Windows	not recommended for animal rooms. For other areas, if provided, fitted with fly screens	not recommended for animal rooms. For other areas, if provided, fitted with fly screens	all windows closed and sealed.	no windows recommended (If with windows: breakage resistant and sealed)	no windows recommended (If with windows: breakage resistant and sealed
20. Animal Room: Cages Solid-Sided, Cages Ventilated or Filtered, Restraining Devices.	n/a	n/a	as required	as required	required
21. Vacuum Outlets (if provided) Protected by HEPA Filters & Liquid Disinfectant in Traps	n/a	n/a	required	required	required if central vacuum systems are used
22. Other Liquid & Gas Services Protected by Backflow Preventers	n/a	n/a	required	required	required
23. Sewer & Other Vent Lines Protected by HEPA Filters	n/a	n/a	required	required	required
24. Ventilation (**Facility**):	ducted exhaust required	ducted exhaust required	ducted exhaust required	required	required

Table 9 -1
General Containment Guidelines

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
Individual Supply & Exhaust Air Systems. (For animal facilities, HVAC to be provided as per latest edition of *Guide for Care and Use of Laboratory Animals)*					
Single Pass (No Recirculation)	required	required.	required	required	required
Directional Air Flow	required	required	required	required	required
Pressure Gradient	recommended for animal rooms; n/a for other areas.	recommended for animal rooms; n/a for other areas.	required	required	required
Supply/Exhaust Coordination (Exhaust Confirmed before Supply Operates)	n/a	n/a	required	required	required
HEPA Filtered Supply and/or Exhaust	n/a	n/a	HEPA exhaust recommended	HEPA supply & exhaust for labs; HEPA supply and 2 in series HEPAs exhaust for high risk areas	HEPA supply & exhaust for Cabinet Lab; HEPA supply and 2 in series HEPAs exhaust for Suit Areas
25. Ventilation (Containment Equipment): Class III BSC	n/a	n/a	HEPA supply filters & tandem (2 in series) HEPA exhaust filters	HEPA supply filters & tandem (2 in series) exhaust filters.	HEPA supply filters & tandem (2 in series) exhaust filters
Class I and II BSC	n/a	n/a	Class II; HEPA supply and exhaust	Class II: HEPA supply and exhaust	Class II; In Suit Lab, HEPA supply and exhaust
26. DDC and Building Automation Systems	to be considered	to be considered	required unless impractical	required	required

Table 9 -1
General Containment Guidelines

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
27. Leak Tightness Testing & Certification of Critical Components of the Biological Containment System Prior to Final Acceptance of the Completed Work	n/a	n/a	BSC, HEPA filter assemblies (if required), welded ductwork (if required).	BSC, HEPA filter assemblies, containment room, and welded ductwork.	BSC, HEPA filter assemblies, containment room, and welded ductwork.

9.5 SPECIAL DESIGN ISSUES

9.5.1 General

This section provides special design issues to be addressed in the design of BSL-3, BSL-3 Ag and BSL-4 facilities. If a feature is required only for a specific biocontainment level, it will be noted.

9.5.2 Architectural Elements

A. Facility Layout

A containment area shall be separated, by controlled access zones, from areas open to the public and from other laboratory personnel, who do not work within the containment area.

During the development of the POR, the A-E, the RPM, the RPR and the RPSO will coordinate to ensure maximum possible compliance with the requirements of UFAS, consistent with the successful performance of the facility’s research mission.

Each laboratory module of the containment facility shall be capable of accommodating a biological safety cabinet.

Adequate means of egress shall be provided from all laboratories without breeching containment or promoting cross contamination. Airlocks, when required, shall be provided and located at transitional points between the spaces of different biocontainment levels through which personnel and/or materials must pass. The design must include storage areas for chemicals and chemical wastes.

Animal facilities shall be designed to provide an adequate number of rooms to assure proper separation of species or tests, isolation of individual projects, quarantine of animals, and routine or specialized housing of animals. Separate areas will be provided for the diagnosis, treatment and control of the diseases of laboratory animals. These areas will provide effective isolation for the housing of animals either known or suspected of being diseased, or of being carriers of disease, from other animals.

When animals are housed, storage facilities shall be provided for feed, bedding, cages, supplies and equipment. Storage areas for feed and bedding shall be separate from the areas where any tests are conducted, and shall be protected from infestation and contamination. Perishable supplies shall be preserved by appropriate means. Portable fencing or dividers, restraining devices, and tables and carts as needed are to be provided.

B. Room Envelope and Interior Finishes

The design shall include construction materials and finishes that are compatible with research programs, activities taking place in the spaces, and decontamination methods. Materials and finishes for spaces that will accommodate large animals (holding rooms, corridors, necropsy facilities, etc.) need to be especially durable, to withstand impact and abrasion, and high temperature and humidity, and high pressure cleaning agents. Floors should be of seamless or epoxy or troweled epoxy materials, impervious, abrasion resistant, nonslip when wet, cleanable, and able to withstand animal feces, urine and disinfectants, and to be washed with 180 degree F water containing detergents and deconning liquids under hose pressure. The floor must be non-skid, but not abrasive to the animals. The facility’s animal care veterinarian must be consulted on the proper flooring material. The flooring materials for containment greenhouses shall be vinyl ester resin, polyurethane resinous mortar, or a similar material. Walls should be constructed of glazed masonry units with an epoxy grout, or of concrete blocks with industrial-grade epoxy paint. Drywall ceilings are not acceptable for animal spaces; cement board or plaster with an impervious finish that can withstand the same cleaning conditions as the walls is required. For insect facilities, the A-E will select lighting systems and color schemes that will draw insects away from exits and toward locations where they can be easily captured.

Openings in walls, floors, and ceilings through which utility services and air ducts penetrate shall be sealed to prevent release and to permit space decontamination. These openings can be effectively sealed by the use of sleeves and the application of a liquid silicone plastic. Seals shall be installed on both sides of all penetration openings, at locations that can be easily inspected and maintained.

Facility doors shall have locks and /or key card access to control admittance.

Airlock doors must have flat or low thresholds to provide for easy movement of carts and animals, and to allow accessibility for physically challenged personnel. The sill must be high enough above the finished floor to prevent water from pooling and causing corrosion, and to prevent abrasion of the door gasket.

All laboratories shall be provided with adequate casework, and storage areas for respirators, if required. Work surfaces shall be impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat.

Any window in the laboratory will be breakage-resistant and sealed.

9.5.3 Mechanical Elements

A. Airflow Patterns. For isolation purposes, separate air handling systems shall be provided for non-containment and containment areas.

Each air handling system serving a containment space shall be designed to supply 100 percent outside air for heating, ventilation and air conditioning. The A-E will perform a life cycle cost analysis on all 100 percent outside air systems to determine if an exhaust air heat recovery is economically feasible. The HVAC system shall be on emergency power.

Direction of flow. The established direction of air flow shall be from less contaminated to more contaminated spaces, and shall remain unchanged under all conditions. Airflow direction within a containment space shall be from the entrance door toward the rear of the space. All rooms must be provided with a visual monitoring device that indicates and confirms directional inward airflow at the laboratory entry.

Airflows. The air flow rate to each room shall remain reasonably constant. Air flow rates shall not be varied for purposes of temperature controls. Room air change rates per hour generally shall be 6 to 8 for offices, and 8 to 10 for laboratories; the HVAC systems for animal rooms shall be designed for 15 air changes per hour at full filter loading, although they will normally be operated in the range of 10-12 air changes per hour, or to meet the latest AAALAC standards. The A-E shall consider setbacks of normal airflow to conserve energy during times of low or no occupancy.

Negative Pressures. A series of differential pressures of approximately 0.05 in wg (12.5 Pascal) between separate functional spaces shall be used to control the direction of movement of airborne particles. Air pressures shall be more negative in those zones at higher risk for contamination by biohazardous materials than in those with lower risk. At some locations, strong winds can cause abnormally high and low temporary atmospheric pressure conditions near the building. The A-E must use care to ensure that, in sensing and responding to these unusual outside pressure conditions, the controls of the facility's HVAC systems maintain the proper pressure relationships among and between the various levels of the containment spaces.

B. Supply and Exhaust Systems

Insect Screens. For facilities using insects for research, provide screens on diffusers and registers.

Location. For ease of maintenance, the active components of HVAC systems shall be carefully arranged outside the containment envelope. Space for doing maintenance work must be provided around equipment.

Capacity. The capacity of the exhaust system, fan, motor and drive shall be 15 percent greater than the capacity of the supply air system.

Controls. The HVAC system shall be controlled by an electronic direct digital control (DDC) system, unless it can be shown to be impractical by the A-E for reasons of economy, operation, maintenance or some other basic reason.

Heat Recovery. Heat recovery studies shall be conducted for all 100percent outside air systems.

Gas-tight ductwork. Exhaust ductwork (including all joints and seams) for contaminated air shall be made pressure tight, as determined by passing the specified in-place acceptance test at + 4 inches wg.

Air filtration. The exhaust air from all types of containment equipment, and all types of containment spaces, shall be filtered through high-efficiency particulate air (HEPA) filters before being discharged to the outside. HEPA filtration shall also be provided on the supply air side where required by this document. HEPA filters shall be provided on exhaust systems serving insect-rearing facilities to generally improve air quality and to trap insect scale, which may cause allergic reactions. The 99.97 percent efficiency filters listed by the National Sanitation Foundation (NSF) shall be specified.

Pre-filters shall be located upstream of all HEPA filters (supply and exhaust) to prevent premature loading. For supply side applications, pre-filters are typically installed at air handling equipment intakes to protect coils and other system components. In addition to those pre-filters, consideration shall be given to the installation of additional pre-filters, located after the supply air fans and immediately before the supply HEPA filters. These will protect the supply side HEPA filters in the event that an access door located between the intake pre-filters and the HEPA filters is opened to a dirty environment while the building is operating under a negative pressure.

Pre-filters shall be installed upstream of all exhaust HEPA filters to prevent premature loading of those HEPA filters. Consideration shall be given to locating these exhaust pre-filters within the containment space where they can be changed by the facility staff without impacting the system's operation or compromising the containment barrier. The used pre-filters would be decontaminated before removal from the containment area, as is other solid waste leaving the facility.

The specifications will require in-place testing of the HEPA filters to assure the integrity of the filter frame seal to the filter housing and that no damage occurred during shipping or installation. Specification of the 99.97 percent (at a minimum), factory-tested HEPA filters is required.

<u>HEPA Filter Location and Housings</u>. The supply and exhaust HEPA filters shall be located as close as possible to the containment space to minimize the length of containment ductwork. The HEPA filter housings shall be selected to allow physical isolation from the ductwork using bioseal dampers (meeting all of the factory and field testing and certification requirements of ASME N509 and N510), or any other approved mechanical means, to allow in-place decontamination of the filters before they are removed, and to allow certification testing after they are replaced. The HEPA filter housing units shall be fabricated to allow reasonably convenient scan testing, decontamination and replacement of the filters. The HEPA filter housing arrangement shall allow ease of access for a human of standard proportions. Access ports for the use of chemical agents to perform all actions necessary to decontaminate the HEPA filters must be functional, properly located and sealable. In some instances,

HEPA filters arranged both in series and in parallel might be required.

Autoclave Venting. Vent hoods and separate exhaust systems shall be carefully provided on both the containment and non-containment sides of the autoclaves to eliminate steam, hot air and odors from the work area. If the autoclave is to be located across a biocontainment barrier, a rubber gasket or some other sort of equivalent bioseal is required at the barrier. To the maximum extent possible, locate all controls and serviceable components on the side out of containment. The steam condensate from the jacket of the autoclave should be recovered, but the steam condensate from the autoclave compartment must go to the contaminated sewer.

Designing for Redundancy. As a general principal, the design must ensure that the failure of one electrical or mechanical device or power source will not shut down a critical biocontainment system or piece of equipment. A critical biocontainment system or item of equipment is one that acts to contain, inactivate, remove or decontaminate biohazardous materials. Examples are: all HVAC systems and their appurtenant equipment and control systems that maintain directional airflows in containment spaces; personnel and suit showers; wastewater decontamination systems; material and space decontamination systems (including carcass disposal facilities); autoclaves and gas sterilizers; compressed air systems serving air-gasketed doors; refrigerators, freezers and cold rooms storing biohazardous materials; BSCs and fume hoods, etc. For the more costly elements being studied, an analysis considering both system redundancy and diversity shall be performed to determine which approach would provide the greater overall economy.

Redundant fans and pumps shall be considered in the design of the supply and exhaust air ventilation systems, and the facility's hydronic systems, respectively. To prevent the overheating of the interiors of animal rooms and containment greenhouses, AN+1" chillers should be considered (N being the number of the best size of chillers for the installation.)

Outside Air Intake. Outside air intakes must be designed so that rain and snow, that could wet or clog the supply air filters, are excluded from the air stream. For northern locations, all 100 percent outside air systems should be provided with a convenient space/access to remove ice accumulations from the outside air intake. The points of intake shall be separated, as far as practicable, from the points of exhaust. In selecting locations, consideration shall be given to the area's prevailing wind patterns. The use of "insect" screens may increase maintenance due to tree lint, mowing debris, etc., and are much more easily/quickly iced up. Air intakes may be better protected with 1/4" or 2" hardware cloth bird screens. A supply HEPA filter is required in certain supply ventilation systems in addition to the prefilters.

Material of Construction. All materials, and their protective coatings, used for the fabrication of all exhaust system components, shall be selected to withstand any corrosive and erosive conditions characteristic of the gases to be handled. In some harsh marine environments, Type 304 stainless steel has been required for supply ductwork to avoid rusting and the depositing of corrosion material into the research spaces.

C. Services

Service Piping. Service piping shall be installed with sloping lines. Use backflow preventers to isolate branch water lines. To avoid crevices that might permit a buildup of contamination, and to promote ease of painting and cleaning, piping not in a wall will not be mounted in direct contact with a wall.

Air Systems. Compressed air, instrument air and containment room pressure taps shall be protected by small, in-line, commercially available HEPA filters.

Floor Drains. Each floor drain will have a 5-inch deep (minimum) trap which is connected directly to the liquid waste decontamination system. All drain cleanout plugs must be located within the containment zone. Floor and sink drains shall be equipped with insect screens in insect rearing facilities. Since straw, hay and various other bulky materials are frequently used for farm animals, either as food or as bedding, all floor drains should be equipped with traps and cleanouts, and shall have a means of flushing readily available. The minimum size of the sewer pipe for farm animals is normally 6 inch, but shall be coordinated with the design approach to decontaminating the liquid wastewater and to handling the solids in the wastewater stream. If possible, the drains in the facility should be the same size to minimize maintenance and protection problems. These floor drains are always kept filled with an effective disinfectant.

Waste Disposal. The A-E is required to investigate Alternative Treatment Technologies in solving the waste disposal issue at the facility.

Vacuum System. Individual vacuum pumps are highly recommended for use in BSL-3Ag and BSL-4 laboratories. If a central laboratory vacuum system is used, it shall not serve areas outside of the containment spaces, and in-line HEPA filters shall be placed as near as practicable to each use point or service cock. HEPA filters shall be installed to permit in-place decontamination and replacement. Vacuum receiver tanks must be fitted with a single HEPA filter, with decontamination ports for the tank itself and for the mechanical pump.

Waste Lines. Waste lines must prevent the release of untreated waste to the environment. Consideration shall be given to providing double containment piping for waste lines leaving BSL-3Ag and BSL-4 spaces. The A-E will consider requiring: (1) a leak alarm system for the annular space between the two pipes; (2) a means of deconning the annular space; and (3) a verifiable means of deconning the interior of the carrying pipe from the floor drain to the effluent treatment system.. Protection of the environment from contaminated waste venting shall be accomplished with HEPA filters in the vent lines. Additionally, the waste venting system shall be connected into the containment space ventilation system in such a manner that the waste venting system will operate at a lower static pressure than the containment rooms served.

Sprinkler Systems. For all types of containment spaces, the A-E and the RPSO will determine, on a case by case basis, if sprinklers are required. The A-E shall perform a risk assessment to identify whether the greater hazard is posed by: (1) a fire in the facility not equipped with sprinklers; or (2) the sprinkler discharge becoming contaminated, and, in turn, contaminating the environment. This risk assessment shall include life safety considerations, potential economic loss, building combustibility, nature of the biohazardous materials, value of the research being performed, etc. Whenever sprinklers are to be installed, the A-E and the RPSO will determine how the biologically contaminated sprinkler discharge shall be treated.

Other Utilities. Water and gas services to the containment facility shall be protected by backflow prevention devices.

Hand Washing Facility. A foot, elbow, or automatically operated hand washing station shall be provided near the exit of each functional space. The sink shall be constructed of materials, such as stainless steel or epoxy-coated resins, which are resistant to possible chemical and other spillage. The drain shall have a removable, cleanable strainer to prevent solid materials from getting into the drainage system.

9.5.4 Electrical Elements

A. Distribution Panels. Separate power and lighting distribution panels shall be provided for containment and non-containment spaces. All distribution panels shall be located outside of containment spaces.

B. Conduit and Wiring. Conduit in containment spaces shall be exposed. In locations where conduit is not subject to physical damage, PVC conduit may be considered. In all other locations, conduit shall be rigid steel, hot-dipped galvanized type. An approved means shall be detailed and included in the design to prevent circulation of air inside or around electrical conduits in the following situations:

1) On the inside openings of any conduit going from a non-containment space to a containment space, or going between containment spaces of different levels; and

2) On any opening between the outside of the conduit and the wall, floor or ceiling that separates a non-containment space from a containment space, or that separates containment spaces at different levels.

All seals shall be installed at locations readily accessible for inspection and maintenance.

For areas outside containment, the use of rigid/PVC conduit systems with specialized seals is not required.

C. Lighting Fixture Installation. Fluorescent lighting fixtures shall be installed flush against the ceiling to prevent dust accumulation. In an animal room, the fixture arrangement is critical due to extensive cleaning and vermin control requirements. Recessed fluorescent fixtures, with prismatic lenses, fixture faces flush with the ceiling, and with triple gaskets are typically used in animal rooms. Gaskets are used between the lens and the frame, the frame and the housing, and the housing and the ceiling. All lenses must be mounted smooth side out to provide an easily cleanable surface. When the room face of the fixture is the containment barrier and the lamps and ballasts are serviced from outside containment, the requirements for containment wiring would not apply. In some instances, sealed and removable fixtures might be a feasible option.

D. Lighting Levels. Animal rooms require multi-level lighting arrangements. A night cycle of 0-1 foot candles, a day cycle of 30-50 foot candles with a wide spectrum fluorescent light source, and a cleaning cycle of 70-100 foot candles are required. Night levels should be as low as possible, with as few light leaks as possible from corridors or nearby rooms. The lighting levels should be regulated by a computer-controlled system.

E. Distribution System. In an animal facility, redundancy of the electrical distribution system is critical. The recommended form of power distribution for an animal facility is the secondary selective radial (or the double-ended) system.

F. Redundant Emergency Power. A standby generator shall be provided, to be automatically switched on in case of a power outage, to serve life safety (e.g., egress lighting, animal room lighting, fire alarms, fire pumps, smoke control, elevators for the disabled) and critical equipment (exhaust systems, fume hoods, sump pumps, freeze protection systems, environmental rooms for long term samples or experiments, selected refrigerators and freezers within lab areas, fuel pumps, and boilers). A priority list of the life safety and critical equipment to be supplied with emergency shall be developed by the A-E, the RPSO, and the RPR.

G. Receptacles. Waterproof, duplex outlets shall be placed at convenient locations throughout the room, located so as to be inaccessible to the animals. All circuits should be equipped with GFCI devices.

H. Special Systems. The A-E shall investigate whether special systems such as Uninterrupted Power Supplies, voltage regulation equipment to ensure utility power to the facility does not vary more than +/- 10 percent, line conditioners to regulate electric power to special items of equipment to +/- 1 or 2 percent, isolation transformers, special shielding, etc., are needed by the facility.

I. Building Automation System. A complete and expandable Building Automation System (BAS), capable of performing energy management, signaling, monitoring, communications, and reporting functions, shall be provided for the facility, unless it is judged to be impractical for the same reasons as cited for DDC systems.

J. Interlocks. All air locks, pass boxes and double-door sterilizers shall be equipped with interlocks so that both doors cannot be opened simultaneously. The supply and exhaust ventilation air fans shall be interlocked to prevent positive pressurization of a containment space in the event of an exhaust fan failure.

K. Decontamination. The electrical system must have sufficient circuits and power to support the facility's decontamination needs and activities.

9.6 BID DOCUMENT PREPARATION

9.6.1 Scope

This section provides special requirements for the preparation of plans and specifications for a biocontainment facility.

9.6.2 Summary of Biological Containment Design Elements

During the pre-design and design efforts for a biological containment facility, the RPSO or APHIS certification officials need to be kept appraised of how the requirements of Chapter 9 are being addressed in the project. These individuals may or may not be skilled in reading and interpreting construction drawings and technical specifications. In order to expedite the review of the biocontainment design features, the A-E shall provide a separately bound Summary Document which outlines the approaches to the project containment requirements and provides information regarding the key features of the facility's design. This document shall be provided as part of each progress submission.

As a minimum, this Summary Document shall include the following:

A. A set of schematic drawings at adequate scale to illustrate the following:

1) A floor plan of the facility which delineates the containment spaces and bioseal doors and indicates the Biological Safety Level each space should be designed to meet.

2) A typical section of the building or greenhouse which shows the construction of the ceiling and wall assemblies which comprise the containment boundary and equipment and distribution space relationships.

3) A pressure zone diagram showing the pressure gradients between spaces, including symbols (arrows) indicating the air flow direction from less contaminated to most contaminated.

4) Schematic of mechanical systems to include HEPA filtration, redundancy, primary monitoring and control points, and line of demarcation between the containment side and the "clean" side of systems.

5) Schematic of the biological waste treatment system showing containment methods and treatment capacity calculations.

B. A typed narrative description on 8 1/2 x 11 inch paper which includes the following:

1) Copies of all correspondence related to research program definition, risk assessment, and RPSO or APHIS designation of space BSL classification.

2) Copies of all correspondence related to waivers from Chapter 9 requirements.

3) A narrative description of options considered and proposed methods to meet the following containment design principles:

   a) Movement, control and decontamination of personnel and materials in and out of the containment space.

   b) Physical isolation and security of containment spaces.

   c) Handling and treatment of solid and liquid wastes leaving containment spaces (to include animal bedding and carcass disposal where applicable).

   d) Type of construction of all architectural elements comprising the containment barriers.

   e) Description of types of finishes for the containment area with respect to durability, ease of cleaning and disinfection, and chemical resistance.

   f) Description of mechanical systems to include maintaining required pressure gradients, system redundancy, and filtration schemes. Include diagram/sketch for HEPA filters access for DOP scanning.

   g) Description of the electrical systems and the emergency back-up systems.

   h) Description or diagram of methods proposed to seal barrier penetrations.

   i) Description of proposed testing methods for rooms, ductwork, HEPA filters assemblies, etc.

   j) Description of the building and process control system discussing ability to control, monitor, and record critical functions.

   k) For insect facilities and greenhouse facilities which are certified by APHIS, the summary shall address the applicable facilities criteria on a point by point basis and shall address barriers and means employed to contain the appropriate insect species.

9.6.3 Location Access and Special Conditions

Each project location will have specific procedures for biosecurity and physical security that will apply to the Contractor and all contractors and subcontractor employees. The plans and specifications, typically in Section 01000, shall fully describe all location requirements and special conditions so that the Contractor fully understands the requirements, and that they may be enforced by the contract conditions.

The contract documents shall address:

A. Sign-in/out locations and procedures for workers, site visitors, suppliers, etc. and maintenance of a log of contractor personnel on the site.

B. Use of security or ID badges and/or keycards on contractor/subcontractor employees and vehicles.

C. Worker Right to Know/Hazard Identification training to be completed prior to beginning work--including if training will be required for supervisors, foremen, and/or all workers, delivery persons, etc.

D. Delivery procedures and requirements.

E. Special shower out and clean up procedures.

F. Limitations of workers to visit farms following work at the site.

G. Parking for contractor/subcontractor employees and service vehicles.

H. Access routes and roads to the work location within the site.

I. Warning that contractor/subcontractor employees shall not enter buildings and facilities not specifically a part of the project due to disease control and health requirements.

J. Requirements for contractor-supplied jobsite sanitary facilities, phone service, storage trailers, and jobsite offices.

K. Restrictions and/or authorizations for contractor use of existing utility services, including water, sewer, compressed air, electricity, and other utilities.

9.6.4 Demolition and Temporary Work

For renovation of a containment facility, the overall work shall be carefully examined for its impact on the adjacent facilities to remain undisturbed. The construction drawings and specifications shall address the following:

A. All materials, equipment and work to be to be provided by or performed by the contractor in support decontamination requirements. All biological decontamination activities for the affected spaces shall be coordinated and monitored by the Government, including the necessary testing and verification functions, prior to turning the space over to the contractor for renovation work.

B. Debris disposal guidelines during demolition shall be defined.

    1) Temporary conditions required by demolition and phasing (dust partitions, security partitions, temporary Air Handling Unit (AHU) requirements, limitations regarding hours of operations in some areas, limitations to use jackhammers or other equipment that may damage containment facilities, etc....

9.6.5 Utilities

The contract documents shall provide guidance on the following issues:

A. Where there is a necessity for a utility shutdown for connections or other purposes, a written request for approval for shutdown must be submitted a minimum of 10 days before the anticipated event.

B. Shutdowns of utilities must not be initiated before approval in writing is received.

C. There will be no unauthorized shutdown of utility services.

D. The guidelines shall identify the number and types of skills of standby support personnel required for the approved shutdown.

E. Specific procedures to be followed for implementing critical operations, such as opening contaminated sewer lines, shall be provided.

F. There shall be no unauthorized altering of any of the following during any phase of construction:

1) building air balance.

2) building air pressure zone levels.

3) any utility that provides support for the safe operation of any containment space.

9.6.6 Containment Boundaries

The contract documents shall include separate floor plans and sections showing all elements which comprise the containment boundaries. The drawings shall indicate the location of barriers which may and may not have unsealed penetrations.

9.6.7 Penetration Details and Sealing Openings

The contract documents shall include special details for sealing all penetrations through containment barriers, e.g., structural, ductwork, all types of pipe, conduit, wire, gang boxes, telephone/data cabling, control tubing, etc. These details shall also include methods of sealing all new and existing openings. This shall include any surface materials required to provide a monolithic surface capable of passing the required tests.

9.6.8 Pressure Levels and Directional Airflow

The contract documents shall include separate containment floor plans and schematics showing pressure levels and relationships, airflow directions, and airflow capacities. One common base atmospheric reference point should be used for all mechanical ventilation systems. The effects of dynamic actions (elevators, doors, hood changes) on pressure relationships and system response shall be considered.

9.6.9 Specialized or Uncommon Products

In biocontainment construction, it may be necessary to specify materials and products which are very specialized, not in common use, or which may be hard to find. In such cases, a source of the specialized product should be specified by stating the supplier's name and address, and the trade name of the product. Review these specialized items with the EPM/CO and provide sole source justification, alternate supplier information, and/or documentation as required for compliance with Federal Acquisition Regulations.

9.6.10 Testing Requirements

The specifications shall list all testing to be performed by, and all documentation and certifications to be provided by, the contractor. An itemized list of the equipment to be tested, and of the types of testing required shall be approved by the RPSO and included in the contract documents. For containment areas, the requirements for testing of ductwork, BSC's and rooms must be specified. Unless specifically addressed in another manner, all testing listed in Appendix B shall be witnessed by an Independent Testing Agency hired by the Government. At a minimum, the following equipment and systems shall be tested and validated.

A. Leak tightness of the supply and exhaust ductwork, at the pressures specified.

B. Factory-testing of HEPA filters, filter housings, isolation valves and other critical components.

C. Field-testing of HEPA filters and housings after installation.

D. Differential pressures and/or directional airflows between adjacent areas.

E. Field testing of biological safety cabinets.

F. Pressure decay testing of containment spaces.

9.6.11 Project Close-Out Requirements

The contract documents shall clearly define the project quality assurance and close-out requirements. Issues to be addressed in the specifications shall include: warranties, certifications, inspection punch lists, equipment start-up and testing, system start-up and testing, biocontainment testing, acceptance criteria, documentation of testing and reporting test results, etc. The A-E will provide a listing of all proposed testing and close-out requirements to the RPSO for approval prior to incorporation in the final contract documents.

9.6.12 Commissioning

A. A properly designed and constructed biocontainment facility, including its structural and mechanical safety systems, must meet predetermined performance criteria and be operational upon completion of construction. The integrity of the critical components of the biological containment systems shall be verified by the testing and certification requirements listed in Appendix B.

B. On a predetermined need basis, and/or when specified by national, department, agency standard, rule, regulation or code, the systems of a biocontainment facility must also be periodically be evaluated in meeting the performance criteria. Detailed records of the activity and the test results should be maintained indefinitely at the facility.

C. Certification of the facility, including structural components and safety systems, should be included as part of the overall commissioning processes normally undertaken to verify that the design and construction meet applicable standards and that the facility can operate in accordance with the design intent.
It is essential that the facility satisfy itself that it has met the required predetermined standards before putting the biocontainment facility into service.

D. Initially, the facility must pass a series of inspections and tests to meet standards that have been pre-developed, authorized, and specified in the design and construction documents before biohazardous agents are used in the facility. These shall be specified in addition to the desired outcomes by the commissioning team identified prior to initiation of construction activities.

E. These predetermined standards for the initial and periodic testing must be realistic, achievable, repeatable, and be statistically valid. They must also be performed without degradation to the facility or mechanical system that is being tested. In addition, they must be applicable for the degree and type of risk that is anticipated with regards to biohazardous agent use with those standards identified upfront that will be used for periodic evaluation.

Appendix 9A: Project Team Roles and Responsibilities as They Relate to Biological Safety Issues:

9A-1. Research Programs Safety Officer (RPSO)

The RPSO performs a risk assessment for the research program to be conducted in a given facility and will make the determination which of the level of biological safety required for the research activities and specific details required accomplishing these requirements. The RPSO retains final authority for decisions on these issues and is the sole authority for granting waivers or deviations from standard biosafety level requirements. The RPSO relies upon the Research Program Representative for an accurate description of the proposed research program.

During the design phase, the RPSO participates in reviewing and approving all design submissions with primary emphasis on biological safety issues. The RPSO will provide written concurrence with the final design documents.

During the construction phase, the RPSO will be invited to participate in construction progress meetings. The RPSO provides clarification of biological safety criteria, and will be consulted for concurrence on construction changes that relate to biological safety matters.

9A-2. Research Program Representative (RPR)

The RPR is usually the Location Coordinator, Research Leader, or Laboratory Director. The RPR prepares the description of the research program for use by the RPSO in determining the type of biological containment required.

During the design phase, the RPR is responsible for reviewing and approving all design submissions with primary emphasis on function, program, and special local issues/interest. The RPR will provide written concurrence with the final design documents.

During the construction phase, the RPR participates in regular construction progress meetings, clarifies established program criteria information, is always consulted for concurrence on construction changes that relate to research program requirements, and is informed of all other changes.

9A-3. Engineering Project Manager (EPM)

The EPM is an ARS Architect or Engineer whose primary responsibility, with other Project Team members, is to ensure Agency needs is met within the approved scope, budget, and schedule. The EPM provides technical oversight and direction and is assigned to the project early in its conception during the time of establishing the project scope and budget. The EPM role will continue throughout the planning, design, and construction phases of the project. The EPM will serve as the lead point of contact and shall disseminate information to the appropriate Project Team members for their action or involvement. It is the responsibility of the EPM to see that all Project Team members are kept advised of the actions, plans, and progress of the project. All Project Team members will keep the EPM advised of their needs and concerns. The EPM also is the lead point of contact between the Project Team and contractors for day-to-day business, working within the terms of the contracts.

During the planning phase, the EPM will coordinate the development and review of the Action Plan and Fact Sheet which summarizes the general scope, budget, and schedule for the project for approval by the Administrator. The EPM will work closely with the RPR in the development of the preliminary POR's for the project. After consulting with other Project Team members, the EPM will prepare a design Statement of Work (SOW) for the project and a cost estimate for all professional services. The EPM will chair the A-E Evaluation Board to evaluate and recommend the A-E selection for a particular project.

During the pre-design and design phases, the EPM will be designated as the Contracting Officer's Representative (COR) and will act as the principal liaison with the A-E firm. The EPM will coordinate A-E visits with the members of the Project Team, conduct design progress meetings and design reviews, review all A-E submittals, and make recommendations to the CO for approval of payment. During the development of the POR, the EPM will ensure that the project complies with the approved Action Plan and Fact Sheet and that the RPSO has provided information regarding the appropriate biological safety levels for the research spaces. The EPM will take the lead to ensure that all Project Team members, including the A-E and the DR, incorporate all project requirements of the POR and that the documents are in compliance with applicable codes and safety standards.

During the construction phase the EPM is usually appointed as the COR. The assignment as COR is made at the beginning of the contract by an official designation letter from the CO outlining the responsibilities, authority, and limitations. A copy of this designation letter will be provided to both the contractors and the Project Team members.

The COR is responsible for interpreting technical data in the A-E, construction, and

CIC contracts. The COR may approve minor changes to the project that do not affect the program requirements, price, scope, or performance time of the contracts. Such changes will be documented and communicated to the Project Team. The COR will provide the CO technical and administrative recommendations and documentation regarding changes to terms and conditions of these contracts.

The COR is responsible for ensuring that all Team Members are kept advised of the actions and progress of the project. Working within the terms of their delegation, the COR is usually the primary point of contact for day-to-day business between the Project Team and the A-E, the construction contractor, and the CIC contractor.

9A-4. Area Office Engineer (AOE)

The AOE serves as the technical advisor and resource to the Project Team during the planning, design, and construction phases of all projects within his/her Area. It is the responsibility of the AOE to see that the Area and location personnel are advised of the actions and status of projects during all phases. The AOE is responsible for coordinating the involvement of Area and location personnel, such as the Area Safety and Health Manager (ASHM), Location Monitor (LM), Location Administrative Officer (LAO), and others as appropriate. The AOE will assist the Project Team by addressing location specific technical questions and coordinating the review comments from the Area and location personnel.

During the planning phase, the AOE is usually involved in the development and review of the POR, Investigative Report, and SOW for A-E services.

During the design phase, the AOE will review the design submittal with particular emphasis on location specific issues such as utility requirements or unique location requirements.

During the construction phase, the AOE will provide assistance to the Project Team and is invited to participate in progress meetings, equipment testing, and final inspections.

9A-5. Location Engineer (LE)

At those locations which have an onsite Location Engineer, many of the responsibilities of the AOE may be delegated to the LE. The LE will insure that location specific issues are addressed in the design documents and may be required to assist with coordination with location personnel and local government entities.

9A-6. Area Safety and Health Manager (ASHM)

The ASHM serves as the safety, health, and environmental advisor and resource to the Project Team during the planning, design, and construction phases on projects within his/her Area. The ASHM shall be consulted on safety, health, and environmental issues.

During the planning phase, the ASHM may be consulted to provide input on developing the POR and the SOW for design. The ASHM will assist in the preparation of the variances on safety, health, and environmental issues during the planning and site investigation phases. Also, the ASHM may assist in prioritizing safety, health, and environmental items to be incorporated in the SOW for design.

During the design phase, the ASHM may, as assigned, review the design submittal and develop priority for safety, health, and environmental items to be incorporated into the contract documents.

During the construction phase, the ASHM is to ensure that all appropriate safety, health, and environmental management related regulations are in place. The ASHM may participate in final inspection and acceptance of the project.

At locations where a location safety or biocontainment officer is available, they may be delegated most of the responsibilities outlined for the ASHM.

9A-7. Location Safety and Health Manager (LSHM)

At locations which have an onsite Safety and Health Manager, the many responsibilities of the ASHM may be delegated to the LSHM. The LSHM will ensure that location safety and health issues are addressed. Responsibilities of the ASHM may also be delegated to the LSHM, and the LSHM may work in concert with the RPSO.

9A-8. Industrial Hygienist and Safety Manager (IHSM)

The facility's or Center's IHSM would be responsible for industrial safety requirement issues as they relate to design of the new or renovated biocontainment facility.

9A-9. Architect-Engineer (A-E)

The A-E is a private contractor who provides professional services of an architectural-engineering nature with primary emphasis on the design of research facilities, laboratory support facilities, and administrative facilities. For biocontainment facilities, knowledge and experience in the design of containment facilities will be a critical selection factor. The design is performed under the supervision of a registered or licensed professional architect or engineer as required in the State where the project is located. The A-E also provides investigative studies, assists in quality assurance of the construction project, assists in project management, reviews submittals during construction, and provides consultative services as needed.

During the planning phase, the A-E finalizes the POR, and prepares the Environmental Assessment and other investigative reports as may be required.

During the design phase, the A-E develops conceptual drawings and provides a preliminary cost estimate. After approval of the conceptual plans, the A-E is tasked with preparation of the final design and working drawings in a manner which incorporates the various adjustments approved through the design review process. Upon approval, various submittals of plans, specifications, and cost estimates are submitted for program, technical, and budget review through completion of final design. The A-E may formally conduct presentations at the various stages of design development and shall provide complete documentation of all such meetings. The A-E shall prepare waiver requests for any deviations from the biological containment standards outlined in this chapter.

The A-E is tasked with incorporating all necessary biological containment features into the construction documents to insure that the facilities meet all standards for the biological safety level assigned to the individual spaces by the RPSO. The design effort will include evaluation of unique requirements for biocontainment measures and will require technical recommendation regarding how the requirements of Chapter 9 are best met for a given facility. The A-E must be particularly sensitive to the testing and accreditation requirements necessary for acceptance of the facility and to the unique maintenance requirements of the containment envelope and equipment.

During the post-design and construction phase of the project, the A-E may be required to participate in the pre-bid, pre-construction, and other meetings. The A-E may be tasked to review and approve shop drawings, material submittals, review and comment on construction contract modifications, and other related activities as directed by the Government. The Government may confirm construction compliance with design intent through a separate inspection contract or may contract for these services through the design A-E firm.

9A-10. Design Reviewer (DR)

The DR is an independent contractor who provides professional services to review the design submissions prepared by the design A-E. The DR is required to perform services under the supervision of a registered or licensed professional architect or engineer. For biocontainment facilities, knowledge and experience in the design of containment facilities will be a critical selection factor.

The DR is to provide assurance to the Government that the design A-E is proceeding in accordance with the project requirements. The DR will review the major design submittals including cost estimates, referencing project requirements cited in the design A-E contract, (i.e., final POR), geotechnical study, applicable Codes and Industry Standards, and good practices of design. The DR will use the ARS Design Review Check List as part of his/her review and will be responsible for seeing that all project requirements are being satisfied.

The DR will be tasked to perform value engineering studies for major construction projects, when required. The DR may be tasked to perform the services of a CIC for major construction contracts.

9A-11. Construction Inspection Contractor (CIC)

The CIC is an independent contractor, generally an A-E firm, whose primary role is to provide quality assurance that the construction project is being constructed as designed and to provide oversight to the Quality Control Plan of the construction contractor. The CIC will consist of a CIC manager that has access to a technical staff that can report to the project site in a timely manner on an as-needed basis. For major construction projects, the CIC responsibility may be assigned as a task order to a construction management firm or an A-E firm separate from the design A-E.

The CIC will monitor the Quality Control Plan of the construction contractor and ensure that special test results, material certifications, etc., are obtained as required. This is particularly critical in testing of biological containment envelopes and mechanical equipment as outlined in this chapter. In cases where test results or certifications, etc., are not satisfactory, the CIC will take immediate action to notify the construction contractor's superintendent and the COR.

The CIC is to report to the COR all findings, observations, and communications with the construction contractor. A daily construction log will be maintained by the CIC, and daily Quality Assurance reports will be submitted concurrently to the CO and COR. If it is identified that the construction contractor has made deviations from the plans, the CIC will document these observations and bring them to the attention of the construction contractor's superintendent, the CO, and the COR.

Appendix 9B: Testing and Certification Requirements for the Critical Components of Biological Containment Systems

9B-1. General

This section provides the requirements for testing and certification that must be conducted at the factory and/or the field to verify the containment integrity of the critical components of biological containment systems. Copies of all testing and certification results are to be made to the facility. These copies will be retained indefinitely by and at the facility.

9B-2. Testing and Certification of Biological Safety Cabinets

Biological Safety Cabinets shall be tested in accordance with the latest version of NSF Standard 49, Class II (Laminar Flow) Biohazard Cabinetry.

9B-3. Testing and Certification of HEPA Filter Assemblies

A. Factory Testing. The filter housing pressure boundary shall undergo factory testing per ASME N5-1989 to 10" w.g. with a maximum permissible leak rate of 0.2 percent of the housing volume per hour. The filter element sealing surface shall be factory tested by the pressure decay method as specified in ASME N 510-1989.

B. In Place HEPA Filter Testing. Field test and provide written certification of all HEPA filter units with Polyalphaolefin (PAO) after installation to verify that the filters do not contain pinhole leaks in the filter media, the bond between the filter media and the filter frame and the filter frame gasket to filter housing.

Filter testing is intended to be completed in a similar manner to industry standards for certification of HEPA filters in Biological Safety Cabinets. The testing contractor may submit an alternate written testing procedure for approval by the RPSO prior to making filter certifications. If the alternate testing procedure is not approved, the following procedure shall be used.

C. Approved Testing Procedures

1) Utilize an aerosol photometer with either a linear or a logarithmic scale and a threshold sensitivity of at least 1 x 10 -3 micrograms per liter for 0.3 micrometer diameter PAO particles and a capacity for measuring 80-120 micrograms per liter concentration. The air sampling rate shall be at least

1 cfm.

The PAO generator shall be the Laskin nozzle(s) type which generates an aerosol of PAO particles by flowing air through liquid PAO. The compressed air supply to the generator shall be adjusted to 20 psi, measured at the entrance to the nozzle and downstream of all restrictions. The nozzles shall be with liquid PAO to a depth not to exceed 1 inch.

2) Adjust the air flow to approximately ten percent of the design air flow rate of the filter. Place the PAO generator to uniformly introduce PAO aerosol upstream of the High Efficiency Particular Air (HEPA) filter. Measure and record the upstream PAO concentration approximately in the center of the filter face.

For linear readout photometers (graduated 0B100), adjust the instrument to read 100 percent while using at least one Laskin type nozzle per 500 cfm airflow, or increments thereof. For logarithmic readout photometers, adjust the upstream concentration to 1 x 10-4 above the concentration necessary for one scale division (using the instrument calibration curve).

3) With the nozzle of the photometer probe not more than 1 inch from the surface, scan the downstream side of the HEPA filters by passing the probe over the entire filter surface in slightly overlapping strokes. Scan the entire periphery of the filter, and the junctions between the filter media and the filter frame, and the filter frame and the housing. Scanning shall be done at a transverse rate of not more than two inches per second.

4) Identify and repair all points of leakage which exceed 0.01 percent of PAO penetration at any point, measured by a linear or logarithmic photometer for acceptance.

9B-4. Testing and Certification of a Containment Room

A. General. The purpose of testing the containment room or envelope is to determine if the walls, floors, ceilings, penetrations, and other containment barrier features have adequate integrity to prevent leakage of air from the containment space. Testing is typically completed by subjecting the containment area to negative or positive air pressure in excess of the anticipated operating conditions, and monitoring the containment air pressure over a test period. Testing and Certification will typically consist of three progressive steps:

1) Pretesting for gross leaks by raising/lowering the containment space air pressure to about 2 inch W.C. (125 Pascal), then looking and listening for major leaks.

2) Soap bubble pretesting.

3) Pressure decay testing for final certification.

An individual containment testing plan shall be developed for each project and the Contractor's role shall be clearly identified in the project specifications. The Contractor's role may include: (a.) full responsibility for testing and documentation through the use of third-party testing subcontractors; (b.) sealing and repairs as needed to comply with Owner completed/subcontracted testing; or (c.) simple visual inspection. If third-party testing is to be coordinated by the Contractor, the project specifications shall include prior testing experience and submittal of qualifications prior to approval of the testing subcontractor.

For new construction, the Contractor will typically have greater responsibility for testing and certification than for renovation work, where access conditions will vary and all existing conditions may not be known. The project approach may also vary depending on the availability and expertise of location or agency safety staff.

B. <u>Pretesting</u>

The integrity of the containment space to prevent leakage will largely be the result of the care used by the Contractor and subcontractors to install products in accordance with the plans and specifications. The project quality assurance/quality control measures should include pretesting prior to testing for certification--even if the Contractor is not responsible for final acceptance testing and certification.

Prior to testing, supply and exhaust ventilation openings shall be sealed closed, and all doors and other openings through the containment perimeter shall be placed in their normal closed positions. If the doors in the containment perimeter are not gasket sealed, they will need to be temporarily caulked or otherwise sealed to complete the testing. The testing plan should address how the openings are to be sealed.

A calibrated digital or inclined manometer shall be installed across the containment perimeter in a manner to minimize interference with wind or ventilation turbulence and to accurately represent the interior and exterior differential air pressure. The manometer shall have a display with capabilities to be easily read to an accuracy of 0.05 inch W.C. (10 Pascal) and capability to accurately read pressures to 3 inches W.C. (750 Pa).

When pretesting for large/gross leaks, the containment space may be pressurized or depressurized by installing a variable speed “blower door” or other approved means to generate a nominal 2 inch W.C. (125 Pa) differential pressure across the containment perimeter. The building surfaces, joints, penetrations, etc., are then inspected for air leakage and sealed in accordance with the plans and specifications. The testing plan should include a warning that generating excessive negative or positive pressures can apply significant stress to the facility, and may cause damage that will be repaired at the Contractor’s expense. The testing plan and specifications should also remind the Contractor to complete sealing repairs while the space is not under test pressures, and that adequate time is to be allowed for sealants to properly cure before retesting.

Following completion of sealing of all leaks identified at 2 inch W.C. (125 Pa), pretesting may proceed to soap bubble testing. Depending on the location of the containment barrier and construction, soap bubble testing may be completed under positive or negative differential pressure. Typically testing is completed under negative pressure, when the soap bubbles are readily visible on the inside surface of the containment barrier.

Provide a fan/blower unit with the capacity to create and maintain a 2 inch W.C. (500 Pa) differential pressure for the time required to inspect all surfaces and to mark leaks. As the containment zone is sealed, the fan/blower capacity required to maintain adequate differential pressure becomes significantly smaller. A simple shop vacuum unit may be adequate for a large building. Provide a valve or other means of throttling the fan/blower unit to slowly ‘load” the building with pressure differential, and to keep from creating too large a pressure differential and causing damage to the structure.

Apply a soap or detector solution (e.g., a liquid detergent with a low surface tension, or a commercial test solution such as “Leak-Tek,” “Search,” or “Snoop”) to all joints, corners, sealed penetrations, or other locations which could be point sources of air leakage. Potentially porous construction surfaces such as wood, masonry units, and mortar joints should be carefully checked. Mark all locations of bubble formations and air leaks. Remove the pressure differential and repair the leaks in accordance with the plans and specifications. Following adequate curing time, repeat the soap bubble testing.

Repeat testing and sealing cycles until it appears that the containment zone will pass pressure decay testing. If a ball valve is located in the fan/blower piping from the containment zone, the valve can be closed to seal the containment zone. With the valve closed, monitor the time for the containment pressure to drop from 2 inches W.C. (500 Pa) to 1 inch W.C. (250 Pa). If the time approaches 20 minutes or more, the containment zone may be ready for pressure decay testing.

C. Pressure Decay Testing and Certification

Prepare for testing by closing openings at the perimeter of the containment envelope and setting up testing equipment as described for pretesting. The fan/blower unit shall be capable of creating a 2-inch W.C. (500 Pa) pressure differential in the containment zone, and shall have a ball valve in the piping to the containment zone to allow the room/zone to be sealed once the testing pressure differential has been reached.

Testing shall be completed under generally stable conditions of outside wind, temperature, barometric pressure, and humidity. Testing shall be under negative differential pressure with respect to the surrounding environment. Air pressure testing ports/openings for the digital or inclined manometer instruments shall be located where the readings will not be affected by wind, air disturbances, or traffic.

D. Pressure Decay Testing Procedure:

1) Operate fan/blower unit to slowly (5 to 10 minutes) bring the differential pressure to 2 inches W.C. (500 Pascal).

2) Close the valve between the fan/blower and the test zone to seal the containment zone at 2 inches W.C. negative pressure with respect to the adjacent areas.

3) Record the differential pressure each minute for 20 minutes.

4) Slowly open the seal valve to allow the room/containment zone to return to normal pressure.

Decay testing may be repeated after a 20 minute wait period. Visually inspect the containment surfaces between testing and make repairs as necessary. If the acceptance criterion is not met, repeat the soap bubble testing and make repairs before retesting.

E. Acceptance Criterion:
Two consecutive pressure decay tests demonstrating a minimum of 1 inch W.C. (250 Pa) negative differential pressure remaining after 20 minutes, from an initial negative pressure differential of 2 inches W.C. (500 Pa).

F. Reports:
At a minimum, reports for each decay test shall include start time, start and end room temperature, date, manometer data (brand, model, serial number, date of last calibration, full scale reading, and smallest scale increment), description of fan/blower unit and control means, tabulation of pressure differential readings for each test minute, a graphical plot of test data (time on the horizontal scale and differential pressure on the vertical axis), a floor plan illustrating the containment envelope and location of the fan/blower unit, and a description of the test, including seals and blockouts. Reports shall be signed and dated by the person completing the test.

9B-5. Testing and Certification of Gas Tight Ductwork and Isolation Valves

Testing shall include all portions of the gas tight ductwork and filter systems that may potentially be exposed to contamination: from the rooms to the respective isolation dampers on the upstream side of the supply HEPA filters and on the downstream side of the exhaust HEPA filters.

Perform in-place positive pressure testing and written certification. All welds and /or duct joints shall remain fully exposed and accessible for inspection and repair until testing is completed and certified.

A. Preliminary testing shall be completed using soap bubble leak detection and/or helium gas to detect leaks for repair prior to final testing and certification. Use of “Freon” or other ozone depleting gas is not acceptable.

B. Certification testing shall be completed using helium gas and a leak detector. The detector shall be an industrial type, capable and adjusted for detection of leaks of 1 x 10 -7 cc/sec. Pressurize duct or assemblies to 4 inches w.g. (1,000 Pa) with a helium concentration adequate to insure leaks will be detected. Scan the exterior surfaces of all ducts, seams, joints, gaskets, and other areas of possible leakage at a distance of 1/4 to 2 inch from the surface and at an approximate rate of 1 inch per second. Acceptance shall be no detected leaks in excess of 1 X 10 - 5 cc/sec.

At a minimum, the testing certification report shall include the date, time, detailed location, description of materials being tested, brand and serial number and calibration date of detector, name and signature of the person completing the testing, and shall be submitted in a format approved by the COR.

C. Alternative pressure testing may be approved on a case-by-case basis if temperature and other environmental conditions will not affect the test. Pressure testing shall be completed by pressurizing the gas tight assembly or ductwork to the specified pressure criteria, closing all valves and monitoring for pressure drop. Acceptance shall be a zero pressure drop in one hour.

9B-6. Testing and Certification of Biocontainment Greenhouses

Greenhouses constructed to meet the BSL-3Ag containment level will undergo the following tests: (a) an air infiltration test conducted according to ASTM E 283-91; the test pressure difference will be 6.24 pounds per square foot positive static pressure; the allowable leakage rate is 0.03 cfm per square foot; (b) a static pressure water resistance test conducted according to ASTM E 331-93; the minimum test pressure will be 10 pounds per square foot; the passing standard is no water penetration to the interior surface; and (c) a dynamic pressure water resistance test conducted according to AAMA 501.1-94; the minimum test pressure will be 10 pounds per square foot; the passing standard is no water penetration to the interior surface.

Appendix 9C: Glossary of Terms

Absolute Filter. See HEPA filter.

Aerosol. A suspension of very fine particles of solid or liquid in air or gas.

Air Lock. A section of corridor isolated by doors, used to separate areas with different levels of biohazard and at different air pressures. An airlock permits the passage of personnel and/or equipment, normally without airflow. Under special conditions, air locks may be pressurized by the addition of a HEPA filtered air supply. When an air lock is used for fumigation, the doors shall be gas tight and the room exhausted by a dedicated exhaust system equipped with HEPA filtration.

Airtight. See "Gas tight."

Aircraft Grade Compound. A sealing compound used for sealing biological safety cabinets and for other caulking uses where a gas tight seal is required.

Alternative Treatment Technology. A validated and certifiable waste treatment process other than incineration or autoclaving.

Animal Cage. Container, generally metal, but may be of plastic, either autoclavable or disposable, designed for permanent housing of (usually individual) animals; may be individually ventilated or open to surrounding atmosphere. Used in both non-biohazard and biohazard areas.

Animal Cage Rack. Stack of steel shelves, generally movable, used to hold animal cages.

Area. Generally used in this section to designate a portion of a building at a given level of biohazard as set off from adjoining portions of different biohazard levels. Used somewhat interchangeably with "space."

Attic. An important utility service area for the laboratories; contains much service equipment including the central ventilation equipment.

Autoclave. A pressurized vessel using saturated steam under pressure to sterilize or decontaminate materials and equipment.

Back Flow Preventer. A manufactured piping device of the type that has two independently acting check valves and one spring-loaded, diaphragm-activated differential pressure relief valve. It is installed in a water supply line to prevent reversal of water flow in case the supply pressure falls below the downstream pressure. See also "Vacuum Breaker."

Building Automation System (BAS). A computerized system with a multitude of points for measuring and in some cases controlling HVAC system parameters as well as performing fire protection, communications, security requirements, energy management, systems monitoring and reporting functions.

Biocontainment (Biological Containment). The safe methods for managing infectious materials in the laboratory environment where they are being handled or maintained with the purpose of reducing or eliminating exposure of laboratory workers, other persons, and the outside environment to potentially biohazardous materials.

Biohazard. An infectious agent, or a part thereof, presenting a real or potential risk to humans, animals, insects or plants, either directly or through infection, or indirectly through disruption of the environment. In certain regulations, these are referred to as infectious substances.

Biohazard Area. A building area with definite boundaries where hazardous biological work is being carried out, separated from non-biohazard and other biohazard areas by suitable barriers.

Biohazardous Material (Biohazardous Agent). Any pathogenic agent, infectious substance to humans, animals or plants, microbial toxins or materials containing the agent, substance, toxin or materials, including known human, animal, or plant pathogens.

Biohazard Service. A service or utility, such as water or vacuum, which serves a biohazard area and is therefore segregated from similar services to non-biohazard areas even though the service itself is non-biohazard.

Biohazard Suite. A group of biohazard laboratory rooms that is isolated from non-hazard areas and other areas by change rooms and air locks.

Biological. An infectious microorganism or toxin that is being handled in the course of research, development, or testing.

Biological Safety Cabinet, Class I. See “Class I Biological Safety Cabinet.’

Biological Safety Cabinet, Class II. See “Class II Biological Safety Cabinet.”

Biological Safety Cabinet, Class III. See “Class III Biological Safety Cabinet.”

Biologically Separated. Term applied to areas that are isolated from each other by air locks, change rooms, and shower.

Blowcase. See “Waste Collection Treatment Unit.”

Cabinet, Class I. See “Class I Biological Safety Cabinet.”

Cabinet, Class II. See “Class II Biological Safety Cabinet.”

Cabinet, Class III. See “Class III Biological Safety Cabinet.”

Cabinet Array. (Referred to Cabinet Line.) A number of Class III biological safety cabinets joined together. An array may be divided into two or more cabinet systems by gas tight doors or fixed partitions.

Cabinet System. A number of Class II biological safety cabinets joined to provide a single space with a single inlet and exhaust for ventilation.

Cage. See “Animal Cage.”

Cage Rack. See “Animal Cage Rack.”

Caulking. Such as silicone sealant; see also “Aircraft Grade Compound” and “Construction Grade Compound.”

Change Room. The dressing room designated to remove clothing. It may be an exterior “clean” dressing room where “street clothing or clean clothing” is removed prior to entering the laboratory, or an interior “biohazard” dressing room where laboratory protective clothing or “dirty clothing’ has been worn while in the laboratory facility and removed prior to exiting the facility. These rooms may also be connected with a personal decontamination shower or air lock when required by appropriate biosafety level practice.

Class I Biological Safety Cabinet. A prefabricated, ventilated enclosure that provides a physical barrier between a worker and a hazardous operation. It may be used with an open front (or open glove ports or with attached gloves) and a high rate of ventilation away from the operator, like a fume hood, or with a closed front and attached rubber gloves. In the latter use, protection depends upon a negative pressure maintained within the cabinet. The ventilated air exhausts through a HEPA filter.

Class II Biological Safety Cabinet. A prefabricated ventilated enclosure for personnel, product, and environmental protection having an open front with inward airflow for personnel protection, HEPA filtered laminar airflow for product protection, and HEPA filtered exhaust air for environmental protection. Different models are available; See text for description of types.

Class III Biological Safety Cabinet. A prefabricated, gas tight, and ventilated enclosure maintained at negative pressure in which some BL3 or all BL4 work is done using attached rubber gloves with a single HEPA filter on the inlet and a double HEPA filter on the exhaust.

Clean. Has been commonly used in the past to mean "free of harmful microorganisms" but has been replaced by "non-biohazard" (except in the term 'clean change room") to avoid possible confusion with the special meaning (of being dust free) given to "clean room" or "clean area" in the aerospace industry. When used in this chapter, "clean" has its ordinary meaning of 'unsoiled,' without reference to microorganisms.

Clean Change Room. Dressing room for removal of street clothes and donning laboratory clothing before entering biohazard change room through an air lock. (Clean is an exception to the use of non-biohazard.)

Clean Room. See "Clean."

Construction Grade Compound. A sealing compound used for all exterior and interior caulking, except where aircraft grade compound is required (see "Aircraft Grade Compound.")

Containable Space. A space, acting as a tertiary barrier, kept under negative pressure, with its exhaust HEPA filtered. The space is sealed and can be gas fumigated, but is not required to pass a pressure decay test. The space is not considered to be within containment, and any person leaving the area need not take a personal shower

Decontamination. A process whereby viable microorganisms are removed from solutions, surfaces, or materials by filtration, heating, radiation, or chemicals to an acceptable level.

Decontamination Shower. See "Disinfectant Shower."

Demand Factor. Percent of total connected load (for utilities).

Diaphragm Valve. Widely used in biohazard service because of zero leakage at the stem (also referred to as a "Saunders Valve").

Dioctylphthalate. See DOP.

Direct Digital Control. A means of using distributed and programmable microprocessors to perform local control of equipment.

Disinfectant Shower. Unit at exit from ventilated suit area in which suit is externally decontaminated for a specified time, by a mist or spray of disinfectant such as peracetic acid, before being removed.

DOP. The abbreviation for dioctylphthalate, which has been commonly used and specified to generate smoke for the purposes of testing HEPA filters and assemblies. Often replaced with PAO for testing due to concerns about the health effects of DOP.

Exfiltration. (Ventilation Term) ductless flow of air from a space to an adjoining space at lower pressure.

Freon-Tight. See "Gas tight."

Gas Sterilizer. An autoclave that has been designed to permit optional use of a gaseous decontaminates instead of steam for sterilizing materials. Gas sterilizer can be purchased specifically for GAS USE ONLY.

Gas Tight. Free from leakage when subjected to the standard halogen leak test.

Germfree. Free of all microbial life detectable by examination.

Glove Box. See "Class III Biological Safety Cabinet."

Gravity Exhaust. (Ventilation term) discharge of air, resulting only from pressure differential, from a ventilated room to the outdoors through an exhaust duct.

High Efficiency Particulate Air (HEPA) Filter. Often referred to as an Absolute Filter. A throwaway, extended/pleated medium, dry-type filter with: (1) rigid casing enclosing the full depth of the pleats; (2) minimum particulate removal of 99.97 percent for thermally generated monodispersed dioctylphthalate (DOP) smoke particles with a diameter of 0.3 micrometer; and (3) maximum pressure drop of 1.0 in wg (25.4 mm) when clean and operated at rated airflow capacity. Other types of HEPA filters are available; e.g., ceramic sintered metal, etc., for pipeline filtering and other uses.

HEPA. See High Efficiency Particulate Air (HEPA) Filter.

Hood Area. See "Ventilated Suit Area."

Infectious Microorganisms. As used in this chapter, the term is restricted to microorganisms infectious for man, plants or domestic animals.

Infiltration. The ductless flow of air into a space from an adjoining space at higher pressure.

<u>Insect Vector</u>. Any insect capable of transmitting a pathogen from one host to another.

<u>Laminar Flow</u>. Straight-line, eddy-free flow, applied specifically to airflow as a means of controlling spread of aerosols in the ventilation of biohazard work areas. Employed in clean rooms, down flow rooms, and crossflow rooms in the aerospace and pharmaceutical industries.

<u>Magnahelic Gauge</u>. An instrument used to measure differential pressure; i.e., between Class II safety cabinet and a room and/or between a laboratory room and a hallway.

<u>Mask</u>. See “Respirator.”

<u>Mask Air</u>. Piped supply of conditioned air for ventilated personnel suits and hoods. See also “Ventilated Suit.”

<u>Non-Biohazard Area</u>. An area with definite boundaries designed to be free of harmful microorganisms. See also “Clean.”

<u>Microorganisms</u>. In this chapter, when not qualified, refers to infectious microorganisms.

<u>Non-Biohazard Change Room</u>. See “Clean Change Room.”

<u>PAO</u>. The abbreviation for polyalphaolefin which is aspirated into ‘smoke’ for testing HEPA filters and assemblies.

<u>Pass Box</u>. A double-door chamber arranged to permit transfer of material and equipment between two confined spaces of different biohazard levels such as a safety cabinet and the room, two safety cabinet systems, a room and a corridor, etc. May employ steam, gas, or liquid as the decontamination agent. See also “Autoclave.”

<u>Pasteurization</u>. Heat treatment of a liquid under conditions of time and temperature (usually 200 degrees F) that will substantially reduce, but not completely eliminate, the population of microorganisms.

<u>Peracetic Acid</u>. One of the compounds used for disinfecting the one-piece, positive pressure, protective suits.

<u>Peracetic Shower</u>. See “Disinfectant Shower.”

<u>Personal Assistance Alarm</u>. An emergency manual alarm activated by pull station (usually located near an exit) and/or emergency shower flow switch.

Pipe Line Filter. A HEPA filter designed to withstand sterilization.

Plenum. When not otherwise specified, refers to a filter chamber or a filter housing in a central ventilation system.

Polyalphaolefin. See PAO.

Post-Wide Alarm System. A system to detect abnormal operation of any critical or important mechanical device or system. Warning is given at a building annunciator panel and at a central annunciator panel that is manned 24 hours a day.

Pressure-Tight. Free from leakage in a soap test at +4 inches wg pressure.

Receiving Room, Biohazard. An area for holding biohazard equipment and materials until they can be sterilized and passed through double-door autoclaves or gas sterilizers that open into the non-biohazard receiving room.

Receiving Room, Non-biohazard. A service room generally at the rear of the building that is maintained as a non-biohazard area. Supplies delivered to the building are placed in the receiving room before transfer through an air lock to the biohazard receiving room.

Refuse Incinerator. A fuel-fired furnace for the combustion of organic wastes, in which all gases will have reached a minimum temperature of 1400 ^{o}F before discharge.

Respirator. The device that is the last resort or temporary control measure to reduce contaminant exposures in the workplace to feasible levels or to provide sufficient oxygen for breathing. All uses of respirators must be in accordance with a site-specific Respiratory Protection Program.

Rodent-Proof. Incorporating prescribed structural and architectural features in building design that prevent access or harboring of rodents and other vermin.

Safety Cabinet, Class I. See “Class I Biological Safety Cabinet.”

Safety Cabinet, Class II. See ‘Class II Biological Safety Cabinet.’

Safety Cabinet, Class III. See ‘Class III Biological Safety Cabinet.”

Safety Shower/Eye Wash Station. A combination emergency plumbing fixture with drench-type shower and two eye/face wash heads. Installed in every chemical, battery, and radiological use area and as otherwise required.

Sealant. See "Aircraft Grade Compound" and "Construction Grade Compound."

Service Piping. Piping other than waste piping or process piping.

Shower. See "Change Room,' "Disinfectant Shower," and "Safety Shower/Eye Wash Station.'

Speaking Diaphragm. Plastic sheet installed in wall, door, or window to permit voice communication through barrier between areas of different biohazard levels.

Steam Seal. Section of piping between two valves, kept filled with steam when not in use, to isolate a vessel or line from another vessel or line from waste drain lines, etc.

Sterilization. An act or process of destroying all forms of microbial life on and in an object.

Sterilizer. See 'Autoclave.'

Suit Area. See 'Ventilated Suit Area.'

Suite. See 'Biohazard Suite.'

System. See 'Cabinet System.'

Toxin. A metabolic product of microorganisms poisonous to man or animals.

Vacuum Breaker. A device that is installed in a line or tank, where the breaker is not subjected to a downstream back-pressure, to prevent reversal of flow in case of accidental occurrence of an upstream suction.

Ventilated Air Lock. A section of corridor isolated by doors, used to separate areas at different levels of biohazard and at different air pressures, which permits passage of personnel and/or equipment, normally without airflow.

Ventilated Cages. See 'Animal Cage.'

Ventilated Hood. Hood covering entire head, pressurized with conditioned air by same hose system serving ventilated suits.

Ventilated Suit. Pressurized outer garment (including head, hands, and feet), supplied by hose with conditioned air, and worn in areas of high risk from infectious aerosols such as some animal rooms.

Ventilated Suit Area. Area of high hazard in which workers are protected by ventilated suits and which is separated from adjoining area of lower biohazard risk by various barriers including change rooms provided with disinfectant showers.

Vermin Proof. See “Rodent Proof.’

Viewing Panel. Fixed window suitably sealed into an interior wall or door between two areas of different biohazard levels.

Viewing Window. See ‘Viewing Panel.’

Waste Collection Tank. See “Waste Collection Treatment Unit.”

Waste Collection Treatment Unit. A waste collection and treatment unit, generally serving one building, consisting of a tank in which the biohazard liquid waste is collected, sterilized or pasteurized by steam either continuously or batch-wise, and discharged to the main municipal-type sewer system. Commonly called “blowcase.”

Waste Piping. Unless specified as ‘sanitary’ or ‘storm water,’ refers to piping handling biohazard waste (biohazard sewer).

10. ANIMAL FACILITIES

10.1 GENERAL

10.1.1 Scope

This Chapter provides general guidance in the planning and design of animal research and care facilities.

10.1.2 ARS Policy

ARS animal research and care facilities shall be designed in accordance with the Animal Welfare Act (9 CFR Parts 1, 2, and 3) and the latest edition of the NIH Guide for the Care and Use of Laboratory Animals, and other applicable Federal laws, guidelines and policies.

The design of facilities for animal research and care shall provide for living conditions of animals appropriate for their species and contribute to their health and comfort. Design must ensure that all research animals are protected to prevent transmission of diseases among animals and to and from humans.

10.2 ANIMAL WELFARE CONSIDERATIONS

10.2.1 General

The caging or housing system shall be designed carefully to facilitate animal well-being and meet research requirements.

10.2.2 Housing System

The housing system shall:

A. Provide space that is adequate as defined by law and guidelines (See section 10.1.2), permits freedom of movement and normal posture adjustments, and has a resting place appropriate to the species, and exercise (if required by law for the species).

B. Provide a comfortable environment.

C. Provide an escape-proof enclosure that confines animals safely.

D. Provide easy access to food and water.

E. Provide adequate ventilation.

F. Meet the biological needs of the animals; e.g., maintenance of body temperature, urination, defecation, and if appropriate, reproduction.

G. Keep the animals dry and clean, consistent with special requirements.

H. Avoid unnecessary physical restraints; and protect the animals from known hazards.

10.2.3 Caging Systems

The caging systems shall be designed to comply with the Animal Welfare Act (9 CFR Parts 2 and 3) and the NIH Guide for the Care and Use of Laboratory Animals, 8th addition (or later revisions). They shall be constructed of sturdy, durable materials and designed to minimize cross- infection between adjoining units. To simplify servicing and sanitation, cages shall have smooth, impervious surfaces that neither attract nor retain dirt and a minimum number of ledges, angles, and corners in which dirt or water can accumulate. The design shall allow inspection of cage occupants without disturbing them. Feeding and watering devices shall be easily accessible for filling, changing, and servicing. Where practical, the design of large animal pens shall include alleys around their sides and back to allow researchers’ access to the animals without having to enter the pens.

10.3 HOUSING FACILITIES - GENERAL

10.3.1 General

Housing facility shall mean any land, premises, shed, barn, building, trailer, or other structure or area housing or intended to house animals.

10.3.2 Structural Strength

Indoor and outdoor housing facilities shall be structurally sound and shall be maintained in good repair, to protect the animals from injury, to contain the animals, and to restrict the entrance of other animals and to restrict the entrance of unauthorized humans.

10.3.3 Water and Electric Power

Reliable and adequate electric power and adequate potable water shall be available. A separate emergency generator shall power all environmental controls that are required for systems essential for the animal's health (e.g., heating, cooling, air supply). Electricity and water use shall be optimized to meet the mission with minimum consumption and waste.

10.3.4 Storage

Supplies of dry food and bedding shall be stored in special rooms in animal facilities which adequately protect such supplies against moisture accumulation and infestation or contamination with vermin.

10.3.5 Waste Disposal

In animal facilities, a separate exit (not used for arrival of clean supplies) shall be provided for the removal and disposal of animal and food wastes. Provisions shall be made for the removal and disposal of animal and food wastes, bedding, and dead animals and debris. Disposal facilities shall be so provided and operated as to minimize vermin’s infestation, odors, and disease hazard.

10.3.6 Washrooms and Sinks

Facilities such as washrooms, sinks, or basins, showers and toilets shall be provided to maintain cleanliness among animal caretakers.

10.4 HOUSING FACILITIES - INDOORS

10.4.1 Heating

Indoor housing facilities for species shall be sufficiently heated when necessary to protect animals from cold and to provide for their comfort. The temperature ranges are listed in the Animal Welfare Act and/or NIH Guide for the Care of Laboratory Animals. The ambient temperature shall not be allowed to fall below 50 ^{o}F for animals not acclimated to lower temperatures.

10.4.2 Ventilation

Indoor housing facilities shall be adequately ventilated to provide for the health and comfort of the animals at all times. Facilities for small animals shall not have windows in the core animal housing rooms. They shall have air intake and exhaust vents and air conditioning organized so that air makes a clean sweep of the room and scrubs all zones where air stratifies (without dead spots) and there shall be at least 15 exchanges of new (not recirculated) air per hour, unless the animal room load is shown to need more or less. Moisture content shall be in the range appropriate for the species. Air conditioning shall be available at all times to maintain the temperature within the range appropriate for the species. The entire ventilation system shall also be served by an emergency generator that assures proper ventilation to the animals during power problems.

10.4.3 Lighting

Indoor housing facilities for animals shall have ample, good quality energy efficient artificial light in the appropriate spectrum and daily light cycle required by the species. Room lighting shall provide uniformly distributed illumination of sufficient light intensity to permit routine inspection and cleaning during the entire working period. Animals that require choice of dark or light during the ‘day” period shall be provided with the means (through cage design) to make this choice.

10.4.4 Interior Surfaces

The interior building surfaces of indoor housing facilities shall be constructed and maintained so they are substantially impervious to moisture and coated with mold-resistant paint whenever possible. Floors should be seamless (to minimize microbial contamination and facilitate cleaning).

10.4.5 Drainage

If closed drainage systems are used, they shall be equipped with traps and so installed as to prevent any backup of sewage onto the floor of the room.

10.5 HOUSING FACILITIES - OUTDOORS

10.5.1 Shelter From Sunlight

When sunlight is likely to cause overheating or discomfort, sufficient shade shall be provided to allow animals kept outdoors to protect themselves from the direct rays of the sun.

10.5.2 Shelter From Rain or Snow

Animals kept outdoors shall be provided with access to allow them to remain dry during rain or snow.

10.5.3 Shelter From Cold Weather

Shelter shall be provided for animals kept outdoors when the atmospheric temperature falls below 50 ^{o}F. Sufficient clean bedding material or other means of protection from the weather elements shall be provided when the ambient temperature falls below that temperature to which the animal is acclimated.

10.5.4 Drainage

A suitable method shall be provided to rapidly eliminate excess water. Minimize discharge of contaminated water and maximize opportunities to recycle used water.

10.6 DESIGN FEATURES

10.6.1 Physical Relationship of Animal Facilities to Laboratories

Locate animal housing areas adjacent to or near laboratories, but separated from them by barriers such as entry locks, corridors, or floors.

10.6.2 Functional Areas

The size and nature of a facility will determine whether areas for separate service functions are possible or necessary. Sufficient animal area is required to ensure separation of species or isolation of individual research projects when necessary; receive, quarantine, and isolate animals; and provide for animal housing.

Generally, facilities shall make provisions for the following service functions:

A. Specialized laboratories or individual areas contiguous with or near animal housing areas for such activities as surgery, intensive care, necropsy, radiography, preparation of special diets, experimental manipulation, treatment, and diagnostic laboratory procedures.

B. Containment facilities or equipment, if hazardous, biological, physical, or chemical agents are to be used.

C. Receiving and storage areas for food, bedding, pharmaceuticals and biologics, and supplies.

D. Space for the administration, supervision, and direction of the facility.

E. Showers, sinks, lockers, and toilets for personnel.

F. A room or suite of rooms for washing and sterilizing equipment and supplies, and, depending on the volume of work, machines for washing cages, bottles, glassware racks, and waste cans; a utility sink; an autoclave for equipment, food, and bedding; and separate areas for holding soiled and clean equipment.

G. An area for repairing cages and equipment is desirable, but may not be practical in the same building if the animal facility is small.

H. An area to store waste prior to incineration or removal.

10.6.3 Noise Control

Noise control is an important consideration in facility design. Equipment noises and low pitch rumbles can lead to animal stress and human caretaker stress. Major equipment such as used for heating and cooling (including emergency generators) should be separated from animal housing rooms and offices for caretakers by partitions designed to minimize transfer of stressful sounds and vibrations.

Within animal facilities, noisy activities, such as cage washing and refuse disposal, shall be carried out in special rooms separated from the for animal housing rooms by a combination of (1) placement of clean storage rooms between those in which noisy activities take place and animal housing rooms, and (2) surrounding the rooms in which the noisy activities take place with extra thick walls.

Noisy animals, such as dogs and nonhuman primates, shall be housed away from rodents, rabbits, and cats.

10.6.4 Water Supply

Animals shall be provided with continuous access to fresh, potable, uncontaminated drinking water, according to their particular requirements. Watering devices such as drinking tubes and automatic waterers shall be provided.

10.6.5 Materials and Finishes

Building materials shall be selected to facilitate efficient and hygienic operation of animal facilities. Durable, moisture proof, fire resistant, seamless materials are most desirable for interior surfaces.

Paints and glazes, in addition to being highly resistant to the effects of chemical solvents, cleaning agents, and scrubbing, shall be highly resistant to the effects of high pressure sprays and impact. They shall be nontoxic if used on surfaces that come into direct contact with animals.

10.6.6 Floors, Walls, and Ceilings

Animal laboratories shall have impervious surfaces and structural joints that are vermin-proof and easily cleaned and decontaminated. The walls and floors shall be monolithic and made of washable and chemically resistant plastic, baked enamel, epoxy, or polyester coatings. The monolithic floor covering shall be carried up eight inches of the wall to prevent accumulations of dirt and wastes in the corners.

Corridors subject to heavy traffic from transportation of cage racks and hand trucks handling feed and wastes shall be constructed of materials resistant to wear and frequent washing with detergents and disinfectants.

Walls in corridors and animal holding rooms shall be provided with buffer strips as necessary to prevent cage racks and hand carts from colliding with the walls and thereby gouging the surface and rupturing the monolithic coatings. Exposed wall corners shall be reinforced with steel or other durable material.

Suspended ceilings shall not be used.

10.6.7 Doors and Windows

Exterior windows and skylights are not recommended in animal rooms because they can contribute to unacceptable variations in environmental characteristics such as temperature. Animal room doors shall be at least 42 inches wide and 84 inches high to facilitate passage of racks and equipment.

Metal or metal-covered doors with viewing windows shall be provided in animal rooms. Doors and frames shall be completely sealed to prevent the entrance or harboring of vermin. Self-sealing sweep strips are desirable. Doors shall be equipped with locks and kick plates and be self-closing. Recessed or shielded handles and locks are recommended.

10.6.8 Heating, Ventilating and Air-Conditioning

Animal laboratories require rigid control of temperature, humidity, and air movement in animal rooms at all times to provide optimal conditions for the health and growth of the species housed therein. The animal rooms shall be capable of an adjustable temperature range between 65 ^{o}F and 84 ^{o}F and a relative humidity range between 30 and 70 percent. All animal rooms must have at least 15 fresh (not recirculated) air changes/hour.

Room air in animal facilities shall not be recirculated. Air pressure in animal rooms and surgical suites shall be higher than that of corridors to minimize contamination of animal rooms. Air pressure in dirty equipment washing rooms shall be lower than that in corridors to minimize spread of contamination and noxious odors. Air pressure in rooms that are used to store clean equipment and materials shall be higher than that in the washing rooms.

10.6.9 Illumination

Lighting shall be uniformly diffused throughout the animal facilities and provide sufficient illumination to aid in maintaining good housekeeping practices, adequate inspection of animals, safe working and healthful for personnel, and the well being of the animals. Over illumination is stressful for some animals (e.g., albinos). These animals should have shaded shelters provided in their cages.

Provision shall be made to use variable-intensity controls to ensure light intensities consistent with needs of animals and personnel working in animal rooms and energy conservation. A time-controlled lighting system shall be used when required to provide a regular diurnal lighting cycle.

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