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Research, Education, and Economics

ARS ❑ CSREES ❑ ERS ❑ NASS

Manual

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

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1. BASIC REQUIREMENTS

1.1 GENERAL

1.1.1 Purpose of the Manual

This Manual establishes Agency policies, design standards and technical criteria 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. <u>Environmental and Functional Needs</u>

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) <u>Arrangement of Space</u>. 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 between scientists.

3) <u>Access for the Disabled</u>. Buildings shall meet the needs of individuals with physical disabilities. Design shall conform to the requirements as outlined in *Uniform Federal Accessibility Standards* (UFAS) or the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG) whichever is more stringent.

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

5) <u>Thermal Environment</u>. The thermal environment shall be such as to provide healthy working conditions for the occupants and proper climatic conditions for the work being performed. Provision of flexibility and suitable control is necessary.

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. Within budgetary and site limitations, designs shall include generous development of well-landscaped, inviting, people-oriented space.

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.

B. Safety, Health and Security

1) ARS buildings shall provide an environment that is safe and healthful 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 risk 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 lead or asbestos free shall be used in ARS buildings. 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 - asbestos or lead etc. If lead or asbestos containing materials are present, the 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, 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.

3) Efficient Utilization. The ratio of net usable 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. To the extent possible, standard commercially available products shall be used.

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 so as to foster maximum competition among bidders, suppliers, and contractors.

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

D. Conservation and Resources.

Energy 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.

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

The Public Buildings Act of 1959, as amended by the Public Buildings Amendments of 1988 (Public Law 100-678) requires that each building constructed or altered by a Federal agency shall be constructed or altered, to the maximum extent feasible, in compliance with one of the nationally recognized model building codes and with other applicable nationally recognized building 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. Uniform Building Code (UBC), maintained by the International Conference of Building Officials. (Http://www.icbo.org/)

B. National Building Code (BOCA), maintained by the Building Officials and Code Administrators. (Http://www.bocai.org/)

C. Standard Building Code (SBC), maintained by the Southern Building Code Congress International. (Http://www.sbcci.org/)

D. International Building Code (IBC), maintained by the International Code Counsel. (Http://www.intlcode.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 not limited to, electrical codes, fire and life safety codes, and plumbing codes. ARS has established the following policy:

A. General. For all projects, the requirements of the National Fire Protection Association (NFPA) National Fire Codes shall apply in lieu of other code references.

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

C. Telecommunications Requirements. For all projects, the Building Industry Consulting Service International (BICSI) Design and Codes shall apply in lieu of other code references.

In addition to BICSI 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)

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 In addition to using the applicable national model codes as a 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, and historic preservation, esthetic qualities of a building, and other similar laws of a state or political subdivision of a state which would apply to the building if it were not a building constructed or altered by the Federal Government.

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.

2) Once the local requirements are identified, the A-E can proceed with the design and develop the documents necessary for a building department plan review as a prerequisite to obtaining a building permit.

3) Upon request, the A-E shall submit design plans for a building department plan review, in close coordination with the project submittal schedule.

4) Local officials may make recommendations concerning measures which should be taken in the construction or alteration of ARS buildings.

The A-E shall then give consideration to any such recommendations, but ARS has the final authority to accept or reject any of the recommendations.

1.2.5 Code Review and Analysis

A. General Code criteria shall be reviewed by each discipline to assure that tasks accomplished during the design of the project meet 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, 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 code/criteria analysis that documents an investigation of various codes and ARS criteria that will govern the design of a specific project. This analysis 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's 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, 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's at 7 CFR 1b, and ARS' 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, quantify, and consider 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. Procedures for conducting environmental reviews of research programs/projects are described in the ARS CRIS Documentation Manual while 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 having signatory authority on all final NEPA documentation. The AD will establish a process to insure 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 an AD 700. One of the following types of decisions must be made for each construction project:

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

B. EA required - Finding of No Significant Impact (FONSI); and

C. Environmental Impact Statement (EIS) required.

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 is not exempt from EA or EIS requirements, 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.)

An EA is a concise public document that is prepared during the planning and design phases of a construction project. The EA include 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 an 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 actions 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, and 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 these 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 Record of Decision (ROD) is published for public review.

1.3.3 List of NEPA Issues for Potential 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?

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 "Interagency Security Committee (ISC) Security Design Criteria for New Federal Office Buildings and Major modernization Projects."

1.4.2 Risk Guidelines

A. 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 ISC Security Design Criteria 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 every countermeasure.

B. Assessment Designation. The ISC Security Criteria use designations ranging from Low to Higher for two purposes. The first is to indicate the severity of the risk to a facility; the second is to designate the appropriate protection level, which means the degree to which the building should offer protection against specific tactics.

C. Risk Factors. For the purposes of the criteria, risk levels are rated Low, Medium/Low, Medium, or Higher. The risk levels are communicated by tactic severity. For example, the vehicle bomb tactic is categorized according to the varying charge weights of the explosives. The lowest weight dealt within this document is considered a Low risk; the heaviest weight is a Higher risk.

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. The Alfred P. Murrah Federal Building, for instance, was the primary symbol of the U.S. Government in Oklahoma City

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. Protection levels. As used in the ISC Security Criteria document, protection levels Low, Medium/Low, Medium, and Higher refer to how the building is to perform during an emergency, and the degree to which the building and its constituent elements should offer protection against specific tactics.

The designation of protection levels, as well as the actual planning, design, and construction of a project should be closely guided by emergency operations objectives to ensure that the resulting Occupant Emergency Plans (OEPs) are reliable, efficient, and cost effective. For example, if an OEP calls for evacuation down a stairwell, the plan for the building should consider where the stairs will discharge, the need for pressurization, and the need for a source of electrical power that will function in that area if a design-basis event occurs. If a project-specific OEP does not exist, use either a generic OEP or an OEP from a similar project.

An entire building should not simply be assigned a single protection level. A facility with a low protection requirement for bomb blast may require a higher protection level for crime; a building's structure may require a higher protection level than its mechanical system; a building requiring low structural protection may need a higher protection level CCTV system.

E. Risk Assessment Methodology. A security risk assessment for each new or major alteration is essential, first because it channels limited budgets to best minimize risk, and second because it optimizes the performance of a building during a criminal or terrorist event.

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 in a manner and on schedule consistent with Section 5164 of Public Law 100-418, Public Law 104-289, Executive Order 12770 of July 25, 1991, and the U.S. Department of Agriculture regulation 1020-38 of May 25, 1992.

A. All ARS new building construction shall be designed and built in metric. All measurements in drawings, plans, specifications, and cost estimates shall be stated exclusively in metric. Commercial and industrial products made to hard metric sizes, dimensions, or characteristics shall be specified, purchased and used to the extent possible. Refer to "*GSA Metric Design Guide*" for general listing and information on hard metric product availability.

B. 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.

C. 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, 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. Copies of these guides maybe obtained from the National Institute of Building Sciences, Publications Department, 1090 Vermont Avenue N.W., Suite 700, Washington, D.C. 20005 (Phone: 202-289-7800).

1.5.4 Exception/Waiver Process

A. Exception Guidance. Federal law and implementing guidance and regulations allow for exceptions to metric usage within certain constraints. ARS has identified the following conditions or circumstances for excepting metric use in construction projects.

1) Metric use will cause an inability of the agency to fulfill its responsibilities under the laws of the Federal government and the United States.

2) Metric use is impractical or will likely cause significant inefficiencies to or loss of markets to U.S. firms such as when a U.S. industry sector is predominantly non metric and cannot easily supply a product to metric specifications, which could give an unintended competitive advantage to foreign-owned firms.

3) Metric use would substantially reduce competition for federal contracts.

B. Request for Waiver from Metric Design. Within the above guidelines, when use of metric is deemed impractical for a specific construction project not generally exempted, a waiver or partial waivers to metric requirements maybe submitted and approved by the Chief, Facilities Engineering Branch (FEB), Facilities Division (FD). Waiver requests shall be submitted to Chief FEB, by the contractor through the EPM (for FD projects) or AOE (for Area projects). Waiver requests will not be considered without the submission of documentation demonstrating the economic or technical infeasibility of a metrication. The evaluation criteria for waiver requests will include such factors as initial life-cycle costs or loss of markets to U.S. firms, and unavailability of industry-accepted metric standards.

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. The *Uniform Federal Accessibility Standards* (UFAS) is a document that sets uniform standards for design, construction, & alteration of Federal buildings so that they are accessible/usable by disabled individuals.

1.6.2 The Americans with Disabilities Act

The Americans with Disabilities Act (ADA) was signed into law in 1990 (P. L. 101-336). 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 to places of public accommodation and commercial facilities by individuals with disabilities.

1.6.3 Accessibility Policy

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 UFAS or ADAAG, whichever is more stringent.

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 1992 (PL 102-486), and including all applicable Executive Orders, 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 Management Plan*, was established in response to these mandates and is based on a policy that fosters cost effective energy 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

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 435, *Energy Conservation Voluntary Performance Standards for Commercial and Multi-Family High Rise Residential Buildings; Mandatory for New Federal Buildings; Interim Rule*.

ARS has adopted the latest edition of ASHRAE Standard 90.1, *Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings*, published by the American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) for energy conservation. The performance of buildings designed according to ASHRAE 90.1 will be equivalent to those designed to 10 CFR 435. Any text phrased as a recommendation in the ASHRAE Standard 90.1 will be understood as a mandatory requirement.

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

1) ASHRAE Standard 100.3 - Energy Conservation in Existing Buildings.

2) ASHRAE Standard 100.5 - Energy Conservation in Existing Buildings - Institutional.

3) ASHRAE Standard 100.6 - Energy Conservation in Existing Buildings - Public Assembly.

1.7.3 Special Design Consideration: Greening the Government

Several executive orders have been issued which promote and mandate the greening of the Federal Government affecting facilities. The A-E’s design therefore shall provide for the protection of the environment through energy efficiency, recycling, pollution prevention, and affirmative procurement.

A. Pursuant to Executive Order (E.O.) 13101, *Greening the Government Through Waste Prevention, Recycling, and Federal Acquisition (September 14, 1998)*, ARS is committed to recycling and buying recycled content and environmentally preferable products, (including bilobated products). The A-E's design shall maximize the use of environmental preferable products.

B. Pursuant to E.O. 13123, *Greening the Government Through Efficient Energy Management (June 3, 1999)*, ARS shall select, where life-cycle cost effective, ENERGY STAR® and other energy efficient products when acquiring energy-using products. The A-E shall specify products that are in the upper 25 percent of energy efficiency as designated by the Federal Energy Management Program (FEMP). The A-E's design shall meet ENERGY STAR® building criteria for energy performance and indoor environmental quality in eligible ARS facilities.

C. Pursuant to E.O. 13134, *Developing and Promoting Biobased Products and Bioenergy (August 12, 1999)*, ARS shall significantly extend procurement activities related to biobased products and services. Biobased products are made from renewable agricultural, animal, or forestry materials, such as vegetable-based lubricants, biofuels, compost, and construction materials. The A-E's design shall maximize the use of cost-effective biobased products and bioenergy.

D. Pursuant to E.O. 13148, *Greening the Government Through Leadership in Environmental Management (April 21, 2000)*, the A-E's 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.

1.8 DESIGN DOCUMENTATION

1.8.1 General

The **A-E**'s 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.

1.8.2 Drawings

A. Drawing Media. All drawings shall be prepared in ink on 24 inches x 36 inches or 30 inches x 42 inches Mylar sheets. 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. The lettering may be produced either freehand, by the use of mechanical lettering instruments, or any of the newer mechanical-electrical lettering devices if they otherwise conform to the height and general style requirements.

C. Drawing Scales. Scales shall be selected to avoid overcrowding and allow for half-size reductions. Scales shall be illustrated graphically on the drawings. Scale of drawings shall be appropriate for high resolution and legibility to include half-size reduced copies.

D. Line Weights. During the initial selection of 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 systems may be utilized for drafting production. However, the computer-generated drawings should exhibit the same general high quality standards specified for manual drafting (i.e., ink pen-plotting, clarity, appropriate lettering size and style, etc.) If CADD is used, it is required (for archival purposes) that each submittal includes a copy of the design specifications and design drawings in electronic format (to be submitted in a CD-ROM). The design specifications are to be submitted in (Portable Documents Format - PDF), and the design drawings are to be submitted in DWG and DWF format - AutoCAD.

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, such as BOCA. No dimension requires the “mm” label. On the drawings the unit symbol is eliminated and only 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. (Specification and calculations cover pages only.)

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

1.8.3 Specifications

A. General. The Unified Facilities Guide Specifications (UFGS) shall be the standard specification for all ARS-FD administered projects. The A-E may purchase a set of current UFGS specifications from:

National Institute of Building Sciences,
ATTN: CCB
1015 15th Street, NW, Suite 700
Washington, D.C. 20005 (202) 347-5710

B. Format. Specifications should be produced according to the Construction Specification Institute (CSI) division format. Each page should be numbered. Numbering of sections within the divisions and section format shall follow CSI recommendations. Specifications should be bound and include a Table of Contents. The specifications shall include instructions to bidders and Division 1, edited to ARS requirements.

C. Editing of Specifications. It is the A-E's 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.

1.8.4 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 records 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.

1.8.5 Cost Estimates

A. Cost estimates must be provided at various stages of the design process and must follow the 16 division systems prescribed by CSI. Costs shall be itemized by sections within the divisions.

B. The A-E shall follow cost trends of the work so that any possibility of 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 thereof.

Appendix 1A: List of Abbreviations

AAALAC	American Association for the Accreditation of Laboratory Animal Care
AABC	Associated Air Balance Council
ACGIH	American Conference of Governmental Industrial Hygienist
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
A-E	Architects and Engineers
AFM	Administrative and Financial Management, ARS
AIA	American Institutes of Architects
AGA	American Gas Association
ANSI	American National Standards Institute
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
BOCA	(National Building Code) Building Officials and Code Administrators
BSC	Biological Safety Cabinet
BSL	Biosafety Level
CDC	Center for Disease Control
CFR	Code of Federal Regulations
CO	Contracting Officer
CPG	Comprehensive Procurement Guidelines (EPA)
CSI	Construction Specifications Institute
DDC	Direct Digital Control
DOE	Department of Energy
ECC	Estimated Construction Cost
EIA	Electronics Industry Association
EO	Executive Order
EPA	Environmental Protection Agency
EPM	Engineering Project Manager
FD	Facilities Division, AFM
FEMA	Federal Emergency Management Agency

FEMP	Federal Energy Management Program
FPMR	Federal Property Management Regulations
GFP	Ground Fault Protection
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
IBC	International Building Code
ICSSC	Interagency Committee on Seismic Safety in Construction
IES	Illuminating Engineering Society
NC	Noise Criterion
NEBB	National Environmental Balance Bureau
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
OSHA	Occupational Safety and Health Administration
P&P	Policies and Procedures
PL	Public Law
POR	Program of Requirements
RCRA	Resource Conservation and Recovery Act
REE	Research, Education, and Economics
SBC	Standard Building Code
SOW	Statement of Work
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
STC	Sound Transmission Class
TIA	Telephone Industry Association
UBC	Uniform Building Code
UFAS	Uniform Federal Accessibility Standards
UFGS	Unified Facilities Guide Specifications
UPS	Uninterruptible Power Supply
USDA	United States Department of Agriculture

VAV	Variable Air Volume

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 is also assumed 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 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.

C. Functionality and Efficiency. Provide a site plan and landscape design that are 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. The A-E’s 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 E.O. 13148: *Greening the Government Through Leadership in Environmental Management* (April 21, 2000), the A-E's 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 site applicable codes and standards that apply to site 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 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 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, 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*.)

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 and by incorporating Crime Prevention Through Environmental Design (CPTED) principles - and decrease the need for costly building engineering solutions to safety concerns.

Note: 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 “Interagency Security Committee (ISC) Security Design Criteria for New Federal Office Buildings and Major modernization Projects.” (See also section 1.4, Security Design)

2.2.2 Site and Landscape Security Design Considerations

A. Vehicular Control. 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) and for a perimeter and 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 CCTV and other surveillance. However, for safety reasons and/or for issues related to camera technology, but 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 of 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. Landscaping 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 CCTV, in accordance with accepted CPTED principles.

2.3 SITE DESIGN ELEMENTS

2.3.1 Physical Character of the Site

To achieve the objectives of good site planning, the designer must analyze the physical character of the site and the surrounding area and develop a design that both respect and reinforce 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 E.O. 11988, Floodplain Management, and E.O. 11990, Wetlands Protection, 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. Disposal of surface water as quickly as possible.

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 3 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 3 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.

2.3.3 Building Orientation

Orientation of structure 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.

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 buildings 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 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.

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 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 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 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 Staff 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, 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 rights-of-way, 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; 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) Site photographs, showing contiguous areas.

3) Existing major 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.

2A-2. 35 Percent Site Design Submittal

A. <u>Design Analysis</u>

1) Listing of applicable codes.

2) Site security considerations

3) Environmental considerations and permitting requirements

4) Responses to the 15 percent Review Comments

B. <u>Drawings and Specifications</u>

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’s plan, showing sizes and locations of 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, water features, etc.

5) Irrigation plan, if applicable.

6) List of Specifications sections to be used.

2A-3 50 Percent Site Design Submittal

A. <u>Design Analysis</u>

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 retainage 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

1) 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, review comments etc.

2) Responses to the 95 percent Review Comments

B. Drawings and Specifications

1) Complete drawing and specification packages suitable to "Issue for Construction."

Appendix 2B: Site Design Coordination Checklist

2B-1. General

This checklist is intended to provide an interdisciplinary coordination review.

A. Piping and other utility locations and inverts at building penetrations coordinated with mechanical 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 coordinated with architectural drawings.

F. Required reinforcement showed 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.

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, 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 at 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 of 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 Staff for information on conducting radon site surveys.)

3. ARCHITECTURE

3.1 GENERAL

3.1.1 Scope

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

3.1.2 Codes and Standards

A. General. The design shall comply with the requirements of the site applicable codes and standards that apply to architectural 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 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 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 1.8, *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 lead or asbestos free shall be used in ARS 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 UFAS and ADAAG whichever is more stringent.

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 ISC Security Design Criteria 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) Public Toilets and Service Areas. 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 the se systems away from attack locations such as main entrance, vehicle circulation, parking, or maintenance area.

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 aesthetic, security, risk, 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.

The preferred parking facility design employs express or non parking ramps, speeding the user to parking on flat surfaces.

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 wails 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 lighted and visible to both patrons in the parking areas and 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 tire-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, grilles, 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 (Footcandles)

	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 Arnerica (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) <u>Emergency Communications</u>. 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 stripping 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 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) Guidelines, Publication 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 Guidelines Publication 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. 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) provide 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 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 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) Class B2 Spaces: 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, ADP areas, computer equipment rooms and rooms housing high speed copiers.

a) The design ambient noise levels must not exceed NC 55. Noise measurements for laboratory space with fume hoods shall be taken with all the fume hoods operating and with sashes opened halfway.

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) Class C1 Spaces: 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 qualified acoustical consultant.

6) <u>Class D Spaces</u>: 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) <u>Class E Spaces</u>: 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) <u>Class F Spaces</u>: 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) <u>Class X Spaces</u>: 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) Should 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 gasketing 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.

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 3 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.

Air infiltration of exterior glazing systems, whether fixed or operable, shall be no greater than 0.20 cfm/linear feet of sash perimeter, per American Society for Testing and Materials (ASTM) E 263 at a static pressure of 6.24 psf. 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 ceiling height, i.e., vertical distance from floor to lowest obstruction above, shall be 8 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 Underwriters Laboratories Fire Resistive 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 15 square feet in size in order to facilitate removal by one person.

C. Doors. Except for closet doors, minimum door width shall be 3 feet and minimum height shall be 6 feet 8 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 Underwriters 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. 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 (i.e., ancillary areas of a building that house its maintenance/ operational support functions).

Building service areas 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. Public Telephones. Provisions for public telephones for building occupants and the public shall be located in, or visible from, each public lobby. For reasons of accessibility, telephone booths are not acceptable; however, recesses may be provided for telephone shelves.

C. 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.

D. 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 (Concepts)

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 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. 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) Acoustical calculations

6) Toilet fixture count.

7) Fire resistance rating of building structural elements.

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

9) Interior finish requirements as they pertain to life safety.

10) Responses to the 15 percent Review Comments

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 and 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 specifications sections to be used.

3A-3. 50 Percent Architectural Design

A. Design Analysis

1) Revisions from the 35 percent submittal.

2) Responses to the 35 percent Review Comments

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

3A-4. 95 Percent Architectural 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.

3A-5. 100 Percent Architectural 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 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 and detailed.

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 systems.

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

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. 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 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.

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 1.8, *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 ISC Security Design Criteria for New Federal Office Buildings and Major modernization Projects. (See also section 1.4, Security Design)

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. For buildings designed to meet Medium or Higher Protection Levels, a blast engineer must be included as a member of the design team. 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 risk assessment.

D. New Techniques. Alternative analysis and mitigation methods are permitted, provided that the performance level is attained. A peer group shall evaluate new and untested methods.

E. Methods and References. All building components requiring blast resistance, shall be designed using established methods and approaches for determining dynamic loads, structural detailing, and dynamic structural response. Design and analysis approaches should be consistent with those in the technical manuals (TMs) below.

The following are primary TMs:

Air Force Engineering and Services Center. Protective Construction Design Manual, ESL-TR-87-57. Prepared for Engineering and Services Laboratory, Tyndall Air Force Base, FL. (1989)

U.S. Department of the Army. Fundamentals of Protective Design for Conventional Weapons. TM 5-855-1. Washington, D.C., Headquarters, U.S. Department of the Army. (1986)

U.S. Department of the Army. Security Engineering, TM 5-853 and Air Force AFMAN 32-1071. Volumes 1, 2, 3, and 4. Washington. DC. Departments of the Army and Air Force. (1994)

U.S. Department of the Army. Structures to Resist the Effects of Accidental Explosions, Army TM 5-1300, Navy NAVFAC P-397, AFR 88-2. Washington. D.C., Departments of the Army. Navy and Air Force. (1990)

U.S. Department of Energy. A Manual for the Prediction of Blast and Fragment Loading on Structures, DOEJIC 11268. Washington, D.C., Headquarters, U.S. Department of Energy. (1992)

F. Structural and Non-Structural Elements

To address blast, the priority for upgrades should be based on the relative importance of a structural or non-structural element, in the order defined below:

1) Primary Structural Elements - the essential parts of the building's resistance to catastrophic blast loads and progressive collapse, including columns, girders, roof beams, and the main lateral resistance system.

2) Secondary Structural Elements - all other load bearing members, such as floor beams, slabs, etc.

3) Primary Non-Structural Elements - elements (including their attachments) which are essential for life safety systems or elements which can cause substantial injury if failure occurs, including ceilings or heavy suspended mechanical units.

4) Secondary Non-Structural Elements - all elements not covered in primary non-structural elements, such as partitions, furniture, and light fixtures.

Priority shall be given to the critical elements that are essential to mitigating the extent of collapse. Designs for secondary structural elements shall minimize injury and damage. Consideration shall also be given to reducing damage and injury from primary as well as secondary non-structural elements.

G. Loads and Stresses

Where required, structures shall be designed to resist blast loads. The demands on the structure will be equal to the combined effects of dead, live, and blast loads. Blast loads or dynamic rebound may occur in directions opposed to typical gravity loads.

For purposes of designing against progressive collapse, loads shall be defined as dead load plus a realistic estimate of an actual live load. The value of the live load may be as low as 25 percent of the code-prescribed live load.

The design should use ultimate strengths with dynamic enhancements based on strain rates. Allowable responses are generally post elastic.

H. Protection Levels

The entire building structure or portions of the structure will be assigned a protection level according to the facility-specific risk assessment. Protection levels for ballistics and forced entry are described in 4.2.3. The following are definitions of damage to the structure and exterior wall systems from the bomb threat for each protection level.

1) Low and Medium/low Level Protection - Major damage. The facility or protected space will sustain a high level of damage without progressive collapse. Casualties will occur and assets will be damaged. Building components, including structural members, will require replacement, or the building may be completely unrepairable, requiring demolition and replacement.

2) Medium Level Protection - Moderate damage, repairable. The facility or

protected space will sustain a significant degree of damage, but the structure should be reusable. Some casualties may occur and assets may be damaged. Building elements other than major structural members may require replacement.

3) Higher Level Protection - Minor damage, repairable. The facility or protected space may globally sustain minor damage with some local significant damage possible. Occupants may incur some injury, and assets may receive minor damage.

4.2.3 New Construction

A. Progressive Collapse.

Design to prevent progressive collapse. Design to mitigate progressive collapse is an independent analysis to determine a system's ability to resist structural collapse upon the loss of a major structural element. It is not a part of traditional blast analysis. It is possible, however, that a blast may be the cause of the removal of structural members. ASCE 7-95 describes progressive collapse and offers additional guidelines.

Designs that facilitate or are vulnerable to progressive collapse must be avoided, At a minimum, all new facilities shall be designed for the loss of a column for one floor above grade at the building perimeter without progressive collapse. This design and analysis requirement for progressive collapse is not part of a blast analysis. It is intended to ensure adequate redundant load paths in the structure should damage occur for whatever reason. Designers may apply static and/or dynamic methods of analysis to meet this requirement. Ultimate load capacities may be assumed in the analyses.

In recognition that a larger than design explosive (or other) event may cause a partial collapse of the structure, new facilities with a defined threat shall be designed with a reasonable probability that, if local damage occurs, the structure will not collapse or be damaged to an extent disproportionate to the original cause of the damage.

In the event of an internal explosion in an uncontrolled public ground floor area, the design shall prevent progressive collapse due to the loss of one primary column, or the designer shall show that the proposed design precludes such a loss. That is, if columns are sized, reinforced, or protected so that the threat charge will not cause the column to be critically damaged, then progressive collapse calculations are not required for the internal event. For design purposes, assume there is no additional standoff from the column beyond what is permitted by the design.

Discussions as an example, if an explosive event causes the local failure of one column and major collapse within one structural bay, a design mitigating progressive collapse would preclude the additional loss of primary structural members beyond this localized damage zone, i.e., the loss of additional columns, main girders, etc. This does not preclude the additional loss of secondary structural or non-structural elements outside the initial zone of localized damage, provided the loss of such members is acceptable for that performance level and the loss does not precipitate the onset of progressive collapse.

B. Building Materials

All building materials and types acceptable under model building codes are allowed. However, special consideration should be given to materials which have inherent ductility and which are better able to respond to load reversals (i.e.. cast in place reinforced concrete and steel construction). Careful detailing is required for material such as prestressed concrete, precast concrete, and masonry to adequately respond to the design loads. The construction type selected must meet all performance criteria of the specified Level of protection.

C. Exterior Walls

1) Design to limited loads - applies to Medium Protection Level. Design exterior walls up to 4 psi (design pressure) and 28 psi-msec.

   The designer should also ensure that the walls are capable of withstanding the dynamic reactions from the windows.

   Shear walls that are essential to the lateral and vertical load-bearing system, and that also functions as exterior walls, shall be considered primary structures. Design exterior shear walls to resist the actual blast loads predicted from the threats specified.

   Where exterior walls are not designed for the full design loads, special consideration shall be given to construction types that reduce the potential for injuries (see 4.2.3.B)

2) Design to full load - applies to Higher Protection Level. Design the exterior walls to resist the actual pressures and impulses acting on the exterior wall surfaces from the threats defined for the facility (see also discussions in 4.2.3.C). The suggested design pressures are 10 psi (incident pressure) and 89 psi-msec.

3) Forced Entry. For doors, criteria shall be based on ASTM standards. Security of swinging door assemblies (ASTM F 476 Grade 30). Measurement of forced entry resistance of horizontal sliding door assemblies (ASTM F 842 Grade 30).

D. Exterior Windows

1) No restriction on the type of Glazing - applies to Low Protection Level.

2) Limited protection - applies to Medium/Low Protection Level. These windows do not require design for specific blast pressure loads. Rather, the designer is encouraged to use glazing materials and designs that minimize the potential risks.

a) Preferred systems include: thermally tempered heat strengthened or annealed glass with a security film installed on the interior surface and attached to the frame; laminated thermally tempered, laminated heat strengthened or laminated annealed glass; and blast curtains.

b) Acceptable systems include: thermally tempered glass and thermally tempered heat strengthened or annealed glass with film installed on the interior surface (edge to edge, wet glazed, or daylight installations are acceptable).

c) Unacceptable systems include untreated monolithic annealed or heat strengthened glass and wire glass.

The minimum thickness of film that shall be considered is 4 mils. In a blast environment, glazing can induce loads three or more times that of conventional loads onto the frames. This must be considered with the application of anti shatter security film.

The designer shall design the window frames so that they do not fail prior to the glazing under lateral loads. Likewise, the anchorage shall be stronger than the window frame, and the supporting wall shall be stronger than the anchorage.

The design strength of a window frame and associated anchorage is related to the breaking strength of the glazing. Thermally tempered glass is roughly four times as strong as annealed, and heat strengthened glass is roughly twice as strong as annealed.

3) Design up to specified loads. Window systems design, i.e., glazing, frames, anchorage to supporting walls, etc. on the exterior facade shall be balanced to mitigate the hazardous effects of flying glazing following an explosive event. The walls, anchorage, and window framing shall fully develop the capacity of the glazing material selected.

Glazing alternatives are as follows;

! Preferred systems include: thermally tempered glass with a security film installed on the interior surface and attached to the frame; laminated thermally tempered, laminated heat strengthened, or laminated annealed glass; and blast curtains.

! Acceptable systems include monolithic thermally tempered glass with or without film if the pane is designed to withstand the full design threat.

! Unacceptable systems include untreated monolithic annealed or heat-strengthened glass and wire glass.

In general, thicker anti shatter security films provide higher levels of hazard mitigation than thinner films. Testing has shown that minimum of 7 mils thick film, or specially manufactured 4 mil thick films, is the minimum to provide hazard mitigation from blast. The minimum film thickness that should be considered is 4 mils.

Not all windows in a public facility can reasonably be designed to resist the full forces expected from the design blast threats. As a minimum, design window systems, i.e., glazing, frames, and anchorage, for the actual blast pressure and impulse acting on the windows up to a maximum of 4 psi and 28 psi-msec (for Medium Protection Level) and up to 10 psi and 89 psi-msec (for Higher Protection Level). A common goal is that 90 percent of the glazing should meet the performance standard specified.

In some cases, it may be beneficial and economically feasible to select a glazing system that demonstrates a higher, safer performance condition. Where tests indicate that one design will perform better at significantly higher loads, that design could be given greater preference.

Where peak pressures from the design explosive threats can be shown to be below 1 psi acting on the face of the building, the designer may use the reduced requirements of 4.2.3.D.

E. Non-Window Openings. Non window openings such as mechanical vents and exposed plenums should be designed to the level of protection required for the exterior wall. Designs should account for potential in-filling of blast over pressures through such openings. The design of structural members and all mechanical system mountings and attachments should resist these interior fill pressures

F. Interior Windows. Interior glazing should be minimized where a threat exists. The designer should avoid locating critical functions next to high risk areas with glazing, such as lobbies, loading docks, etc.

G. Parking. The following criteria apply to parking inside a facility where the building superstructure is supported by the parking structure:

1) The designer shall protect primary vertical load carrying members by implementing architectural or structural features that provide a minimum 6-inch standoff

2) All columns in the garage area shall be designed for an unbraced length equal to two floors, or three floors where there are two levels of parking.

H. Selected Design Areas. For lobbies and other areas with specified threats:

1) The designer shall implement architectural or structural features that deny contact with exposed primary vertical load members in these areas. A minimum standoff of at least 6 inches from these members is required.

2) Primary vertical load carrying members shall be designed to resist the effects of the specified threat.

I. Loading Docks. The loading dock design should limit damage to adjacent areas and vent explosive force to the exterior of the building. Significant structural damage to the walls and ceiling of the loading dock is acceptable. However, the areas adjacent to the loading dock should not experience severe structural damage or collapse. The floor of the loading dock does not need to be designed for blast resistance if the area below is not occupied and contains no critical utilities.

J. Mailrooms and Unscreened Retail Spaces. Mail rooms where packages are received and opened for inspection, and unscreened retail spaces shall be designed to mitigate the effects of a blast on primary vertical or lateral bracing members. Where these rooms are located in occupied areas or adjacent to critical utilities, walls, ceilings, and floors, they should be blast and fragment resistant. Significant structural damage to the walls, ceilings, and floors of the mail room is acceptable. However, the areas adjacent to the mail room should not experience severe damage or collapse.

K. Venting. The designer should consider methods to facilitate the venting of explosive forces and gases from the interior spaces to outside of the structure. Examples of such methods include the use of the blow out panels and window system designs that provide protection from blast pressure applied to the outside but that readily fail and vent if exposed to blast pressure on the inside.

4.2.4 Existing Construction Modernization

Existing structures undergoing a modernization should be upgraded to new construction requirements when required by the risk assessment except where noted in 4.2.4.B. The requirements of new construction apply to all major additions and structural modifications.

A. Protection Levels. Risk assessments based on the new construction criteria shall be performed on existing structures to examine the feasibility of upgrading the facility. The results, including at a minimum recommendations and cost, shall be documented in a written report before submission for project funding.

B. Progressive Collapse. Existing buildings will not be retrofitted to prevent progressive collapse unless they are undergoing a structural renovation, such as a seismic upgrade.

4.2.5 Historic Buildings

Historic buildings are covered by these criteria in the same manner as other existing buildings

4.2.6 Good Engineering Practice Guidelines

The following are rules of thumbs commonly used to mitigate the effects of blast on structures. Details and more complete guidance are available in the Technical Manuals listed in 4.2.2.E and in the references below. The following guidelines are not meant to be complete, but are provided to assist the designer in the initial evaluation and selection of design approaches.

For higher levels of protection from blast, cast-in-place reinforced concrete is normally the construction type of choice. Other types of construction such as properly designed and detailed steel structures are also allowed. Several material and construction type while not disallowed by these criteria, may be undesirable and uneconomical for protection from blast.

A. To economically provide protection from blast, inelastic or post elastic design is standard. This allows the structure to absorb the energy of the explosion through plastic deformation while achieving the objective of saving lives. To design and analyze structures for blast loads, which are highly nonlinear both spatially and temporally, it is essential that proper dynamic analysis methods be used. Static analysis methods will generally result in un achievable or uneconomical designs.

B. The designer should recognize that components might act in directions for which they are not designed. This is due to the engulfment of structural members by blast, the negative phase, the upward loading of an elements and dynamic rebound of members. Making steel reinforcement (positive and negative faces) symmetric in all floor slabs, roof slabs, walls, beams and girders will address this issue. Symmetric reinforcement also increases the ultimate load capacity of the members.

C. Lap splices should fully develop the capacity of the reinforcement.

D. Lap splices and other discontinuities should be staggered.

E. Ductile detailing should be used for connections, especially primary structural member connections.

F. There should be control of deflections around certain members, such as windows, to prevent premature failure. Additional reinforcement is generally required.

G. Balanced design of all building structural components are desired. For example, for window systems the frame and anchorage shall be designed to resist the hill capacity of the weakest element of the system.

H. Special shear reinforcement including ties and stirrups is generally required to allow large post elastic behavior. The designer should carefully balance the selection of small but heavily reinforced (i.e., congested) sections with larger sections with lower levels of reinforcement.

I. Connections for steel construction should be ductile and develop as much moment connection as practical. Connections for cladding and exterior walls to steel frames shall develop the capacity of the wall system under blast loads.

J. In general, single point failures that can cascade, producing wide spread catastrophic collapse, are to be avoided. A prime example is the use of transfer beams and girders that, if lost, may cause progressive collapse and are therefore highly discouraged.

K. Redundancy and alternative load paths are generally good in mitigating blast loads. One method of accomplishing this is to use two-way reinforcement schemes where possible.

L. In general, column spacing should be minimized so that reasonably sized members can be designed to resist the design loads and increase the redundancy of the system. A practical upper level for column spacing is generally 30 ft for the levels of blast loads described herein.

M. In general, floor to floor heights should be minimized. Unless there is an overriding architectural requirement, a practical limit is generally less than or equal to 16 ft.

N. It is recommended that the designer use fully grouted and reinforced CMU construction in cases where CMU is selected.

O. It is essential that the designer actively coordinate structural requirements for blast with other disciplines including architectural and mechanical.

P. The use of one-way wall elements spanning from floor-to-floor is generally a preferred method to minimize blast loads imparted to columns.

Q. In many cases, the ductile detailing requirements for seismic design and the alternate load paths provided by progressive collapse design assist in the protection from blast. The designer must bear in mind, however, that the design approaches are at times in conflict. These conflicts must be worked out on a case by case basis.

R. The following additional references are recommended:

1) Biggs, John M: Introduction to Structural Dynamics, McGraw-Hill. (1964).

2) The Institute of Structural Engineers: The Structural Engineer's Response to Explosive Damage, SETO, Ltd., 11 Upper Belgrave Street London SWIXSBH. (1995).

3) Mays, G.S. and Smith. P.D. Blast Effects on Buildings: Design of Buildings to Optimize Resistance to Blast Loading. Thomas Telford Publications, 1 Heron Quay, London E14 4JD. (1995).

4) National Research Council. Protecting Buildings from Bomb Damage. National Academy Press. (1995).

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 Statement of Work (SOW) 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. 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. Pro-con 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 or uncompacted 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 area 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 permit.

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 city authorities 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 2 feet below the finished grade at the exposed face of the wall. A four-inch diameter weep holes shall be provided for drainage, placed 6 inches above the lower grade at the exposed face of the wall, and spaced not more than 15 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 system 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 EQUIPMENT SUPPORTS

4.5.1 Design Loads

The recommended design live loads shall be in accordance with governing code requirements for intended functional use.

4.5.2 Vibration

Supports for high-speed machinery having heavy vibrational 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 proportion of the weight of rotating or reciprocating part of the machine to 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 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 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.

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, 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 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 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 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 effect of construction operations on 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.

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.

The tendency of adjoining structures to sway out of a phase shall be considered in establishing the width of separation or the adequacy of the structural connection between them. In establishing requirements for an earthquake joint, the A-E shall consider whether it is satisfactory to make the joint width twice that of the static drift of the structure.

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. Not all seismic deficiencies warrant remedial action. Seismic upgrading is an expensive and often disruptive process, and it may be more cost effective to accept a marginally deficient building than to enforce full compliance with current code requirements.

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

a) Federal Emergency Management Agency (FEMA) Publications:

! *NEHRP* (National Earthquake Hazards Reduction Program) *Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, Part 1: Provisions* (FEMA-302A, with 15 maps) and *Part 2: Commentary* (FEMA-303A).

! *Interim Guidelines: Evaluation, Repair, Modification and Design of Steel Moment Frames (FEMA-267) and Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment Frame Structures* (FEMA-267B).

! *NEHRP* (National Earthquake Hazards Reduction Program) *Handbook for the Seismic Evaluation of Buildings–A Pre-standard* (FEMA–310).

! *NEHRP* (National Earthquake Hazards Reduction Program) *Recommended Guidelines for the Seismic Rehabilitation of Buildings, Part 1: Guidelines* (FEMA-273, with the NEHRP maps) and *Part 2: Commentary* (FEMA-274).

b) American Society of Civil Engineers: *Minimum Design Loads for Buildings and Other Structures, ASCE* 7.

c) *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings and Commentary* (ICSSC RP 4) prepared by the Interagency Committee on Seismic Safety in Construction – Recommended Practice 4.

Appendix 4A: Structural Design Submission Requirements

4A-1. 15 Percent Design (Concepts) Submittal

A. Drawings.

1) 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.

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

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 Submittal

A. Design Analysis

1) Listing of applicable 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) 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.

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

6) Responses to the 15 percent Review Comments

B. <u>Drawings and Specifications</u>

1) Framing plans and key details.

2) List of specifications sections to be used.

4A-3. 50 Percent Design Submittal

A. <u>Design Analysis</u>

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) Narrative Description of structural systems

3) 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. Subdrainage 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. 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 have 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 subdrains.

12) Recommendations for foundation and subdrainage, 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 owning 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. Mechanical Design Standards. The design shall conform with the following publications and codes. The term "Recommended" as used in the American Society of Heating, Refrigeration 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 Code for Mechanical Refrigeration.

9) ASHRAE: Standard 62: Ventilation for Acceptable Indoor Air Quality.

10) ASHRAE: Standard 90.1: Energy Efficient Design of New 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

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 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) NEBB: Procedural Standards for Building Systems Commissioning

12) American Society of Plumbing Engineers: ASPE Data Books.

13) 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.

D. <u>Code Review and Analysis and Waiver Process</u>. 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 1.8, *Design Documentation* and Appendix 5A, *Mechanical Design Submission Requirements*.

B. Coordination Checklist. To insure 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 and Life Cycle Cost Analyses

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. Considering the requirements for HVAC on an integrated basis, the A-E shall perform Life Cycle Cost (LCC) analysis comparing three viable energy efficient HVAC systems. 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. For new construction, one HVAC alternative shall utilize a renewable energy source, and one shall be appropriate for the particular site conditions e.g., if district steam or chilled water is available.

Analyses of energy-conserving designs shall include all relevant effects of the building envelope, lighting energy input, domestic water heating, efficient use of local ambient weather conditions, building zoning, efficient part load performance of all major HVAC equipment and the ability of involved building automation equipment to automatically adjust for building partial occupancies, optimized start-stop times and systems resets.

C. Specifying Energy Efficient Products and Equipment

1) The A-E shall specify those energy consuming goods or products which are life-cycle cost effective, including building energy system components lighting systems, office equipment, and other energy using equipment. To assist the A-E's in specifying energy efficient products, the Department of Energy (DOE) provides product energy efficiency recommendations and other information at http: // www.eren.doe.gov/ femp/procurement

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.

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

D. Energy Efficiency/Conservation. The A-E shall explore life-cycle cost-effective efficiency opportunities for steam systems, boiler operation, air compressor systems, industrial processes, fuel switching, cogeneration, and other efficiency and renewable energy technologies. The A-E shall evaluate and consider heat reclaim as energy conservation method.

E. Renewable Energy. The A-E shall incorporate the use of renewable energy and 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.

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 FEMP's Website: http: //www.eren.doe.gov/femp/ resources/ water/ water groupmain.html

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 Executive Order 13123 and have been incorporated into the internet-based “Whole Building Design Guide” that can be accessed at http: //wbdg.org/

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 midrise and high-rise construction. See section 3.4.2, Class X Spaces.

D. Mechanical Chases. Mechanical chases should be closed at top and bottom, as well as the entrance to the mechanical room. 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 in-situ inspection and cleaning. 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 mechanical and fire protection 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 ISC Security Design Criteria for New Federal Office Buildings and Major modernization Projects. (See also section 1.4, Security Design)

B. The mechanical system should continue the operation of key life safety components following an incident. The criteria focus on locating components in less vulnerable area, limiting access to mechanical systems, and providing a reasonable amount of redundancy.

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 4 stories, locate intakes on the 4th floor or higher. On buildings of three stories or less, locate intakes on the roofer as high as practical. Locating intakes high on a wall is preferred to a roof location.

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)

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.

During an interior bombing event smoke evacuation and control is of paramount importance. The designer should consider the fact that if window glazing is hardened, a blast may not blow out windows, and smoke may be trapped in the building.

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 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. 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

A. 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 3 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 4 inches.

D. Special Wastes. 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. 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 noninjurious 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.

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 or boilers. 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 booster pump, a pneumatic system, a constant pressure, or a maintained pressure pumping 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, or transformer vaults. A swing type joint shall be provided for a service line at its entrance to the building.

E. Interior Water Piping. Water distribution systems shall be protected against back flow (the flow of water or other liquids into distributing pipes from a source or sources other than the intended source). Refer to latest editions of the NSPC 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. Fuel or energy selected for water heating shall be determined by availability and cost. Type selected maybe steam, gas, oil, electricity, or solar.

5.3.7 Gas Piping

A. Design. Gas piping shall be designed using the latest edition of NFPA Standard No. 54 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.

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.

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

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

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 5 feet above the floor. Designed indoor temperature will vary with the activity and intended use of the building. The A-E shall utilize his professional knowledge and expertise to identify those instances where ASHRAE design standards may not be appropriate for the researcher's needs. This sensitivity to researchers' needs is critical to the success of the design.

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 1 percent column dry-bulb temperature, with its corresponding mean coincident wet-bulb temperature. Cooling towers shall be selected based on the 1 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

2) Computer Rooms Year-Round

72 ^{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. Infiltration shall be calculated by the ASHRAE crack method. Unless otherwise specified in the project POR, heating load calculations shall be based on inside design condition of 70 ^{o}F DB.

The heating plant shall be sized based on the calculated block heating load for space and process plus an allowance of 20 percent extra capacities.

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 20 percent extra capacities.

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 is contained 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.

3) Non-Laboratory spaces: Ventilation systems shall comply with ASHRAE Standard 62, *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.

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 is 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

Size piping for maximum friction loss of 3.3 feet per 100 feet of straight pipe, or a velocity of 8 feet per second, whichever is larger. 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, solar system loops, or other zones; e.g., primary and secondary loops. Balancing devices shall be provided to allow adjustment.

Except for condenser water systems, piping systems shall be insulated. 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.

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 not exceed 3 percent for low pressure systems and 0.5 percent for medium or high pressure systems. 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 fittings such as heating coils, cooling or filters, transition 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. Smooth elbows with a center radius one and one- half times the width of the duct should be used for rectangular ducts.

F. Volume or splitter dampers shall be provided in ductwork, where necessary, to obtain proper control, balancing, and distribution. A parallel blade automatic control damper shall be used if position control is required. An opposed blade automatic control damper shall be used if modulating control is required. Fire 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. Psychrometric 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.

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.

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.

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

5.4.10 Automatic Temperature and Humidity Control

A. General. Automatic controls for temperature and humidity shall be provided for HVAC systems.

Drawings shall delineate the control type, with standard symbols, schedules, description of operation, sequences, throttling ranges, set points, alarms, etc. Show room thermostats on floor plans.

B. Direct Digital Control (DDC) system with a host computer controlled monitoring and control shall be provided.

1) Controls. Preprogramed stand-alone single or multiple loop controllers shall be used to control all HVAC and plumbing subsystems.

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.

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 appropriate, an economizer cycle will be used when the outside air temperature can provide free cooling.

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.

5.4.11 Start-up, Testing, and Balancing Equipment and Systems

A. Start-up. The A-E 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 A-E 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).

C. Commissioning. The A-E shall prepare contract documents which include provisions for commissioning of the mechanical, plumbing, and fire protection systems.

The documentation shall include the design intent document, pre commissioning checklists, and functional performance test checklists. ASHRAE Guideline 1, The HVAC Commissioning Process, and NEBB Procedural Standards for Building Systems Commissioning, provides guidance regarding commissioning. These standards are not mandatory for ARS projects. However, they do contain principles and procedures which should be considered based on the size and complexity of the project.

5.5 UNDERGROUND HEAT DISTRIBUTION SYSTEMS

5.5.1 General

Underground heat distribution systems shall be designed in accordance with the ASHRAE Handbook Series and standard industry practice.

Appendix 5A: Mechanical Design Submission Requirements

5A-1. 15 Percent Design (Concepts) Submittal

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 at least three 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. HVAC Design Submittal

A. 35 Percent HVAC Design Submittal

1) Design Analysis

a) Listing of applicable codes.

b) Block Loads for Heating and Cooling.

c) Life Cycle Cost Analysis.

d) Description of three potential HVAC systems with recommendations for special spaces such as laboratories.

e) Preliminary controls strategy narrative.

f) Environmental considerations and permitting requirements

g) Responses to the 15 percent Review Comments

2) Drawings and Specifications

a) Locations of mechanical rooms, fresh air intakes and exhaust locations.

b) Single line duct drawings showing preliminary sizes of the mains.

c) List of Specifications sections to be used.

B. <u>50 Percent HVAC Design Submittal</u>

1) <u>Design Analysis</u>

a) Revisions from the 35 percent submittal.

b) Narrative Description of HVAC systems.

c) Block and Room Loads for heating and cooling.

d) Description of energy conservation measures.

e) Preliminary Equipment Selections for major equipment (chillers, cooling towers, AHU's, exhaust fans, pumps, VAV boxes, etc.).

f) Controls strategy narrative

g) Preliminary duct and pipe sizing calculations

h) Preliminary Laboratory Exhaust Plume Analysis

i) Responses to the 35 percent Review Comments

2) <u>Drawings and Specifications</u>

a) Sequences of control.

b) Air flow diagrams.

c) Marked-up specifications.

d) Preliminary schedules

e) Double line duct drawings for mechanical rooms and duct mains

f) Single line duct drawings for branch ducts

g) Locations of mechanical rooms with equipment drawn to scale

h) Locations of fresh air intakes and exhaust locations

i) Duct and piping system schematic

C. 95 Percent HVAC Design Submittal

1) Design Analysis.

a) Any revisions from the 50 percent submittal.

b) Narrative Description of HVAC systems

c) Final Equipment selections showing two manufacturers

d) Final Laboratory Exhaust Plume Analysis

e) Duct and pipe sizing analysis

f) AHU psychrometric analysis

g) Responses to the 50 percent Review Comments

2) Drawings and Specifications

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

D. 100 Percent HVAC Design Submittal

1) Design Analysis.

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

b) Responses to the 95 percent Review Comments

2) Drawings and Specifications

a) Complete drawing and specification package suitable to "Issue for Construction."

5A-3. Plumbing Design Submittal

A. 35 Percent Plumbing Design Submittal

1) Design Analysis

a) Listing of applicable codes.

b) Narrative Description of the proposed plumbing systems, including the following:

– Supply water availability, quality, and pressure

– Fixture count analysis

– Description of any special treatment systems for both supply and waste

c) Environmental considerations and permitting requirements.

d) Responses to the 15 percent Review Comments.

2) Drawings and Specifications

a) Locations of mechanical rooms, water and sewer mains.

b) List of Specification sections to be used.

B. 50 Percent Plumbing Design Submittal

1) Design Analysis

a) Revisions from the 35 percent submittal.

b) Narrative Description of Plumbing systems.

c) Preliminary Equipment Selections for major equipment.

d) Preliminary calculations for water supply, storm, and sewer piping.

e) Responses to the 35 percent Review Comments.

2) Drawings and Specifications.

a) Sequences of control.

b) Riser diagrams and schematics.

c) Marked-up specifications.

d) Preliminary schedules

e) Locations of mechanical rooms with equipment drawn to scale

C. 95 Percent Plumbing Design submittal

1) Design Analysis

a) Any revisions from the 50 percent submittal.

b) Narrative Description of Plumbing systems

c) Final Equipment selections showing two manufacturers for each major piece of equipment

d) Pipe sizing analysis

e) Responses to the 50 percent Review Comments

2) Drawings and Specifications

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

D. 100 Percent Plumbing Design submittal

1) Design Analysis.

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

b) Responses to the 95 percent Review Comments

2) Drawings and Specifications

a) Complete drawing and specification package suitable to "Issue for Construction."

5A-4. Fire Protection Design Submittals

A. 35 Percent Fire Protection Design Submittal

1) Design Analysis

a) Listing of applicable codes.

b) Narrative Description of the proposed fire protection systems, including the following:

- Supply water availability, quality, and pressure, including fire hydrant flow test data

– Narrative describing room occupancy classifications

c.) Responses to the 15 percent Review Comments.

2) Drawings and Specifications

a.) Locations of mechanical rooms, water mains and proposed connections.

b.) Room occupancy classifications.

c.) List of Specification sections to be used

B. 50 Percent Fire Protection Design Submittal

1) Design Analysis

a.) Revisions from the 35 percent submittal.

b.) Narrative Description of Fire Protection systems.

c.) Preliminary Equipment Selections for major equipment.

d.) Preliminary hydraulic calculations.

e.) Smoke control/stairway pressurization analysis where applicable

f.) Responses to the 35 percent Review Comments.

2) Drawings and Specifications.

a.) Riser diagrams and schematics.

b.) Room occupancy classifications

c.) Marked-up specifications.

d.) Preliminary schedules

e.) Locations of mechanical rooms

C. 95 Percent Fire Protection Design Submittal

1) Design Analysis.

a.) Any revisions from the 50 percent submittal.

b.) Narrative Description of fire protection systems.

c.) Final Equipment selections showing two manufacturers for each major piece of equipment

d.) Hydraulic Calculations

e.) Responses to the 50 percent Review Comments

2) Drawings and Specifications

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

D. 100 Percent Fire Protection Design.

1) Design Analysis.

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

b.) Responses to the 95 percent Review Comments

2) Drawings and Specifications

a.) Complete drawing and specification package suitable to "Issue for 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. Minimum amounts of outside air to be admitted during occupied hours shown on drawings; also, minimum ventilation supplied at lowest setting of VAV boxes.

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 meet 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, construction of walls, floors, and ceilings.

4) Verify the location and size of underground or standpipe water supplies.

5) Verify the location and arrangement of all waterflow 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 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 detectors on the drawings and riser diagram meet Code requirements.

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. 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

6. ELECTRICAL SYSTEMS

6.1 GENERAL

6.1.1 Scope

This Chapter presents data and considerations necessary for proper design selection of electrical power source and distribution systems. The criteria covers load estimating factors, electrical power sources, distribution systems, illumination, communication, signaling, special equipment, and repair and alterations for ARS buildings.

6.1.2 Codes and Standards

A. The design shall comply with the requirements of the site 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 must meet or exceed the requirements of the National Electric 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 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.

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 5A, *Electrical Design Submission Requirements*.

B. Coordination Checklist. To insure inter-discipline and intra discipline coordination, a review checklist is provided in Appendix 6B, *Electrical 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.

6.1.4 Economic Design

A. General. Electrical systems shall be designed to permit acceptable competitive bids. Equipment and systems shall be efficient and economical in construction, operation, and maintenance. To avoid excessive initial cost, keep the number of circuits to a minimum without compromising the final size of the feeder or voltage drop of a primary feeder. Where a group of large motors is to be served by a distribution system, establish the most economical voltage for the common size motor, and adopt a voltage for distribution.

B. Economic Analysis. The A-E shall perform an economic analysis of power sources to determine the optimum scheme. The following factors shall be considered:

1) Primary versus secondary metering.

2) Government-owned versus electric utility-owned transformers.

3) Use of medium-voltage motors for large equipment, such as compressors, pumps, etc.

4) Frequency of service interruptions to the extent that they affect the selection of equipment.

5) Amortization costs for replacements or additions.

6) Individual versus combined metering.

7) Cost of power factor correcting capacitors where rate schedules penalize a low power factor.

6.1.5 Energy Conservation

The largest factor in the energy consumption of a building is lighting. The overall efficiency of the lighting system depends both on the individual components and on the interaction of components in a system. A good control's strategy that eliminates lighting in unoccupied spaces and reduces it where day lighting is available can contribute significantly to energy conservation. The best way to institute such controls is through a Building Automation System (BAS).

The A-E shall check with local power companies and include technologies that qualify for rebates.

6.2 ELECTRICAL/ELECTRONIC SECURITY DESIGN

6.2.1 General

A. 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 ISC Security Design Criteria for New Federal Office Buildings and Major modernization Projects. (See also section 1.4, Security Design)

6.2.2 Electrical Security Design Considerations

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. Emergency and normal electric panels, conduits, and switchgear should be installed separately, at different locations, and as far apart as possible. Electric distribution should also run at separate locations.

2) Normal Fuel Storage. Locate normal fuel storage away from high-risk areas. The main fuel storage should be located away from loading docks, entrances, and parking. Access should be restricted and protected (e.g., locks on caps and seals).

3) Emergency Fuel Storage. Provide emergency fuel storage. The day tank should be mounted near the generator, given the same protection as the generator, and sized to store approximately eight hours of fuel A battery and/or UPS could serve a smaller building or leased facility.

4) Emergency Generator. Locate emergency generators away from high-risk areas. The emergency generator should be located away from loading docks, entrances, and parking. More secure locations include the roof, protected grade level, and protected interior areas. The generator should not be located in any areas that are prone to flooding.

   If the emergency generator is installed outdoors at the grade, it should be protected by perimeter walls and locked entrances

5) Utilities and Feeders. Locate utilities and feeders away from high risk areas. Utility systems should be located away from loading docks, entrances, and parking. Underground service is preferred. Alternatively,

they can be hardened.

C. Power and Lighting

1) Site Lighting. Site lighting should 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 with camera requirements.

2) Restrooms. Consider providing emergency power for restroom lighting. Emergency lighting in restrooms may facilitate evacuation or permit limited use during power outages not requiring immediate evacuation. Where daylight is available, emergency lighting may not be required. Emergency power should be provided for exit lighting in restrooms

3) Stairways and Exit Signs. Provide battery lighting for stairwells and exit signs. Self-contained battery lighting should be provided in stairwells and for exit signs as back up in case of emergency generator lag time or failure. As an alternative to battery powered lighting handrails, stair treads, signs, and doors can be painted with phosphorescent paint. Floor-level evacuation lighting systems should also be considered since a bombing event may fill corridors with dense smoke.

6.2.3 Electronic Security

A. General.

Electronic security should be considered early in project planning to help ensure that it is a cost-effective integral part of the facility design. The purpose of electronic security is to improve the reliability and effectiveness of life safety systems, security systems, and building functions. When possible, accommodations should be made for future developments in security systems.

The following are intended to stress those concepts and practices that warrant special attention to enhance public safety. Please consult design guides pertinent to your specific project for detailed information about electronic security.

B. Control Centers and Building Management Systems

Centralization of control center information can improve the reliability and effectiveness of life safety systems, security systems, and building functions. Operational requirements, especially a pre-designed chain of command for various types of incidents, should be carefully considered.

C. Security for Utility Closets, Mechanical Rooms, and Telephone Closets

Security system wiring/conduit should not be accessible in utility/telephone closets. As a minimum, a key system security shall be provided to control access. For medium and higher protection levels, access to mechanical, electrical, and telecommunication rooms should be authorized, programmed, and monitored through pre identification of maintenance personnel. This alternative anticipates a more sophisticated security system for doors.

D. Devices and Alarms

1) Elevator Recall. An OEP may prefer that elevators not discharge personnel on the first floor (lobby) during some events. A button can be provided on the Fire Command Center (FCC) 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 should 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.

2) Intrusion Detection. Basic intrusion detection should be provided for 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 considered especially if local crime conditions justify additional detection measures.

3) Monitoring Provide CCTV monitoring station

4) Closed Circuit TV (CCTV). CCTV monitoring may be required depending on the overall result of the risk assessment. The monitoring should be mainly at entrances, monitored exits, vehicular entrances into parking garages, and loading docks.

All CCTV cameras should be on real-time and 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, should be video recorded. The use of digital video systems should be considered by the designer.

5) Duress Alarms or Assistance Stations. Call buttons should 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 should be calculated from connected load layouts. Determine these factors 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 may be made by assuming watts per square foot of building area.

B. Load Analysis. Analyze characteristics of each load to determine appropriate load estimating factors. Consider items such as environmental conditions of weather, geographical location, and working hours, as the situation dictates.

6.3.2 Estimation of Loads

A. Individual Loads. Individual loads are those with one incoming service. In general, these loads would comprise single structures.

B. Lighting Load. Divide facility area into significant components by function. Determine average lighting level and type of light source for each area.

C. Power Load. Power loads shall include loads other than lighting loads and those served by general purpose receptacles.

D. System Loss. System loss of approximately 6 percent, based on calculated maximum demand, shall be added to the building load.

E. Load Growth. Determine 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. Before determining the size of service and method of distribution to a facility, an economic analysis shall be made to determine the most feasible way of serving this future load.

F. Emergency Loads. Determine emergency power requirements based on three types of loads: minimum essential loads; emergency loads for vital operations; and uninterruptible (no-break) load.

When the three categories of emergency power requirements have been ascertained, determine where local emergency facilities are required, where loads may be grouped for centralized emergency 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 must be sized as follows: panelboards for branch circuits must be sized with 50 percent spare ampacity, panelboards serving lighting only with 25 percent space switchboard ampacity, distribution panels with 35 percent spare ampacity and main switchgear with 25 percent spare ampacity. Spare overcurrent devices shall be provided as well as bus extension for installation of future protective devices.

6.3.4 Selection of Power Source

A. Primary. The primary 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 alone can supply minimum essential operating electric load of the building and, when added to capacity of a primary source, will provide a combined capacity sufficient to furnish the estimated peak demand under mobilization conditions.

C. Emergency. Emergency sources, usually one or more engine-driven, manual or automatic-starting emergency generators, shall have sufficient total capacity to provide electric power demand for vital operations. Vital operations permit power interruption only for relatively short durations. The emergency source shall have sufficient capacity to provide continuous adequate supply for vital operations.

6.3.5 Uninterruptible (No-Break) Power

An uninterruptible power system 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.

The no-break system must be capable of supplying power of suitable quality during voltage fluctuations or surges, or fault or ground conditions. Successful operation of critical spares depends on power system reliability. In designing no-break uninterruptible power supply (UPS) systems, it is important that the system 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.

6.3.6 Installation of Distribution System

Overhead lines shall be avoided. The underground method shall be used if normal conditions exist.

6.3.7 Grounding of Distribution Systems

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 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 (B)

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. Secondary service shall be either 208Y/120 volt or 480Y/277 volt, three-phase, 4-wire service.

B. Service Conductors. Use of more than two conductors in parallel shall be discouraged. Conductors serving the same load shall be of the same sizes and lengths.

C. Metering. Regardless of operating agencies, buildings shall be provided with a revenue primary or secondary metering installation ahead of the main disconnecting device.

D. Service Equipment. Locate equipment at service entrance points. Use circuit breakers. Select the most economical devices to accommodate short-circuit and normal current requirements.

6.4.2 Short-Circuit Considerations

Devices must be able to clear any fault on secondary systems without damage when service conductors are connected to low-voltage network systems, wherein service protective devices and entire utilization system shall be subjected to large short-circuit currents.

6.4.3 Service Equipment Rooms

Utilities shall be accessible, and equipment rooms shall be sized to provide sufficient space for maintenance. If electrical equipment is located in an electrical-mechanical equipment room, adequate space for electrical equipment shall be reserved.

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 utility's requirements.

6.4.5 Service Feeders

A. Number. The number and arrangement of incoming feeders shall be based on requirements for maximum uninterrupted service, large motor inrush characteristics, and the reliability of the distribution system.

B. Capabilities. Electrical rating of each service feeder shall be based on the sum of distribution feeder requirements, future loads, and system demand and diversity factors. Neutrals of secondary services shall be full size, where required, to carry electrical discharge lighting, data processing, or similar equipment loads where there are harmonic currents present.

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 to the exterior wall of the room or vault in which main service disconnecting equipment is located.

6.4.7 Service Disconnecting Equipment

A. Primary Disconnecting Equipment. For projects having only two incoming feeders, each feeder shall be provided with a metal-enclosed interrupter switchgear assembly. Each feeder shall supply two unit substations. Interrupter switchgear for a single incoming feeder may be combined with the unit substation.

B. Secondary Disconnecting Equipment. 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 600 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 application.

6.4.8 Electric Utility Equipment

Service equipment to be furnished and/or installed by the electric utility shall be shown and identified on drawing and listed in specifications. Each point at which material furnished by the utility terminates or is connected to material furnished by the Construction Contractor shall be clearly specified or 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 required on feeder and branch circuits on two levels to achieve selectivity and 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) Reliability 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. Particular care in the application of GFP systems shall be taken when there are a number of ground return paths to the service transformer via building steel and earthground. GFP equipment shall be desensitized by fault current flowing directly to the transformer. Solutions to the desensitizing problem follow:

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 assemblies and for power, distribution, and substation transformers. Rooms shall be located where they will be readily accessible, but free from the danger of flooding. Each room shall be provided with an appropriate number (regarding fire safety) of exit doors with panic hardware which shall open into space that is accessible at all times.

6.5.2 Clearances

Clearances and spacing of electrical equipment shall conform with the requirements of NEC. Aisle widths shall be increased wherever necessary for the use or storage of breaker removal equipment.

6.5.3 Concrete Curbs

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 in the event of tank rupture.

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 with a minimum of one foot-candle illumination. Lights for electrical and mechanical rooms shall be connected to the emergency generator, if available, or shall have 90-minute battery backup.

6.5.6 Ventilation

Provide a thermostatically controlled exhaust fan to remove heat buildups. Where possible, makeup air shall be obtained directly from the outside. Provide fire dampers as appropriate to maintain fire rating. Coordinate requirements with the mechanical design.

6.6 PRIMARY DISTRIBUTION SYSTEM

6.6.1 General Description

The primary distribution system shall consist of Government-owned incoming feeder conduit banks, medium-voltage metal-clad switchgear, distribution feeders and raceways, substations, and auxiliary switchgear and secondary unit substations shall be substituted for the corresponding equipment items indicated above.

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, provided continuity of service is not impaired.

6.6.3 Feeder Raceways

A. Electrical Equipment Spaces. In electrical equipment rooms, electrical closets, and similar spaces, medium-voltage distribution feeds shall be installed in galvanized steel conduits, and horizontal runs shall be overhead. However, cable trays may be used to support medium-voltage distribution feeders in electrical equipment rooms. Exposed power cables shall be fireproofed throughout. Top connections shall be provided to the transformers and switchgear assemblies.

B. Risers. Conduits for medium-voltage feeder risers shall be galvanized steel. When 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.

6.6.4 Primary Substations

A. High Voltage. Where primary service voltage exceeds 15 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. Primary 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, but shall not include reserve capacity.

6.6.5 Secondary Substations

Secondary substations shall articulate unit type, consisting of a transformer and primary metal-enclosed interrupter switchgear and secondary switchboards. 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 secondary selective operation, but shall not be double ended unless specified.

6.6.6 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 bank 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. Breaker closing current shall include spring release coil current and starting current of the spring charging motor.

Ratings for batteries shall be obtained 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 for small projects, and a safety factor of 1.40 for large projects.

Each battery bank shall be provided with static charging equipment fed from an emergency panelboard. Battery bank and charging equipment shall be installed in, or near, the medium-voltage switchgear room. Batteries, racks, charging equipment, auxiliaries, etc. shall be shown on drawings. Adequate space for maintenance shall be provided.

6.6.7 Unit Substations

Primary unit substations shall consist of a primary terminal chamber, a 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 be objectionable.

6.7 SECONDARY DISTRIBUTION SYSTEM

6.7.1 General

Wire and conduit size shall be based on use of copper conductors. Aluminum conductors are not acceptable. Insulation shall be rated 75 ^{o}C or more 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 incandescent lighting, receptacles, small motors, etc.

B. Motors smaller than ½ 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. Feeders supplying all, or part, of the electrical power or service to laboratories shall contain a separate green insulated grounding conductor sized in accordance with the NEC.

6.7.2 Low-Voltage Switchgear Assemblies

Low-voltage switchgear assembly shall be provided for each building and secondary substation that requires secondary service rated more than 600 amperes. Secondary service disconnecting devices and metering equipment, where required, 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.

Switchboards shall be enclosed, dead-front. Low-voltage metal-enclosed switchgear assemblies with low-voltage power circuit breakers may be used when the total load exceeds 2,000 amperes.

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 shall be provided. When possible, switchgear assemblies shall be arranged so that additional units may be installed.

6.7.3 Over Current Protection

Short-circuit protective devices shall provide continuity of service, and short-circuit ratings shall be based on values resulting from system coordination. Selection of over current protective devices for low-voltage switchgear assemblies 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 above 200 amperes. 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 800 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.

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 starters and current breaker disconnects shall be provided, in lieu of separately mounted motor starters, where several motors are located in close proximity. 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 controllers and for indicating their locations on drawings. This information must be given to the electrical engineer who shall be responsible for providing suitable feeder sizes, 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

Distribution panelboards shall be equipped with automatic circuit breakers of the quick-make quick-break type. Lighting and appliance branch circuit panelboards shall be equipped with automatic time delay circuit breakers.

A main distribution panelboard shall be provided with a system that requires secondary service rated 200 to 600 amperes. The main panelboard shall have an over current protective device for each lighting and appliance panelboard. A main distribution panelboard will not be required in a building having two or three lighting and appliance panelboards and a service disconnecting device with a rating of 200 amperes or less.

Branch circuits over current 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 a number of spare over current 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 from 30 to 42 branch circuits, including spares and spaces. The number of spare over current devices and spaces for future over current devices shall not be less than 10 percent of the active circuits. Over current devices shall have 20-ampere ratings, except where higher ratings are required. Over current 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. Plug-in breakers are not acceptable.

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, and critical research equipment. Emergency 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. Electrical closets shall be spaced 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. The latter spacing shall be provided where both 277-volt and 120-volt circuits are fed from the same closet. The above spacing shall be modified to suit underfloor 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 underfloor 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 should have the position more accessible to the underfloor raceway header capacity. Adjacent electrical and telephone closets shall be provided with a 2-inch sleeve for interconnections.

C. Size. Closets shall be ample 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. To minimize sound transmission, dry tape transformers shall be mounted preferably on the wall or hung from the ceiling to afford maximum working floor space. 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 about 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. Ventilation. Ventilation shall be provided, as required, to prevent temperature from exceeding 100 ^{o}F.

G. Lighting. See section 6.11 - Illumination

H. Receptacles. A duplex receptacle shall be provided in each electrical closet. Receptacles shall be installed in the wall 12 inches above the floor and 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. Access to panel for future circuiting and dry tape 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 light loads and to street lighting systems. For protection against mechanical injury, high-voltage direct burial cables shall be provided with a protective covering of steel armor. When corrosion considerations are of importance, 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 avoidance of 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 ducts in same concrete envelopes.

Electrical ducts shall be kept clear of other underground utilities, especially high-temperature water or steam pipes. Acceptable standard materials include fiber, clay, plastic, and soapstone.

When sizing conduits, consider the following: For general distribution, standard design requires ducts of four or 5 inches. For communication duct banks, a minimum size of 3 inches may be acceptable.

Arrangement of Duct Banks. For the best configuration, use an arrangement in two conduits wide. This arrangement requires only a narrow trench, provides good heat dissipation, and enables cables to be more easily stacked on the manhole walls.

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.

Drain ducts to manholes with a constant slope of 3 inches or more per 100 feet. Where two manholes are at different elevations, a single slope following the general slope of the terrain may be the most economical. When grades are flat or crest between manholes, a single slope requires too much depth in one of the manholes.

New underground systems shall include sufficient ducts for planned future expansion.

6.8.3 Manholes and Handholes

Two-section manholes shall be used where power and communication lines follow the same route.

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 curved duct runs. Decrease spacing where necessary to prevent installation damage.

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

Cable costs make up a large portion of initial investment and future maintenance operating costs, and system reliability. These costs are important in selecting underground cables and accompanying protective and operation devices.

6.8.5 Underground Transformers

Use vaults to house transformers and associated equipment for underground distribution systems.

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 NFPA No. 70 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.

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 cables protected by a metal enclosure. All branch circuits shall have a separate green insulated grounding conductors installed in a raceway along with supply and/or neutral conductors.

A. Nonmetallic cable (type NMC, trade name "Romex") or armored cable (type AC, trade name "BX") 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.

C. No more than eight duplex receptacles shall be connected to an individual 20-ampere 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. The branch circuit distribution system type shall be selected based upon a life-cycle cost analysis of at least two competitive systems such as flexible wiring (plug-in) flat conductor cable versus a conventional system (wire and conduit).

G. 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.

H. Harmonic currents on the neutral conductors shall be minimized for circuits serving computers and other electronic analytical equipment. Use of a reduced gauge as allowed by the NEC can be problematic.

6.9.2 Switching

For control of lights, refer to section 6.11

6.9.3 Receptacles

In addition to receptacles required for spaces and equipment described above, receptacles shall be provided in the locations for purposes indicated below. A duplex receptacle, referred to below, is a 15-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 OSHA requirements.

Provide 15-ampere, 125-volt grounded type weatherproof duplex receptacles near air-conditioning or heating equipment.

Provide ground fault interrupters (GFI) protection for each of the following receptacles in addition to those receptacles required to have GFI protection for residential occupancies listed in the NEC: receptacles, 125VAC, 15-, 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 panelboards.

Emergency lights shall be provided for egress, 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 if one foot candle illumination.

Emergency lights shall be supplied from emergency panelboards without switch control. Emergency lighting shall be rapid starting; fluorescent lamps or tubes shall light from cold start within five seconds.

6.10 EMERGENCY POWER

6.10.1 General

Keep requirements for emergency power to an absolute minimum. Facility location will provide detailed data describing their minimum emergency power needs, equipment heat generation, and equipment requiring uninterruptible precise power.

6.10.2 Applications

Emergency power shall be provided for the following:

A. Elevators which require the use of generators.

B. Critical load requirements, e.g., research and storage of research activities.

C. Equipment that must operate without interruption, e.g., laboratory equipment.

D. Fire protection or other safety equipment requiring power in case of interruption of normal power.

6.10.3 Emergency Power Sources

Building size and emergency 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 emergency power source. Batteries and static inverter shall be considered when load does not exceed 20 kVA, provided elevators are not served by them. A single generator shall be provided in 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.

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 emergency light 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 and escalator lighting.

3) Corridor lighting.

4) Exit and emergency lights in essential machine rooms and guard offices, etc.

5) Emergency receptacles in telephone equipment closets.

6) Equipment, such as communication systems and automatic data processing systems, where an interruption might cause a hazard or other serious problems.

7) Pumps to prevent flooding that might damage buildings or contents, and other essential pumps.

8) Essential heating equipment in cold climates.

9) Mechanical HVAC control systems.

10) Emergency loads for generator auxiliary equipment, including:

11) Damper motors, supply and exhaust fans, radiator fans (remotely mounted

radiator only), and generator room ventilation and controls.

12) Fuel oil transfer pumps.

13) Battery chargers.

14) Generator alarms.

15) 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 emergency power to the uninterruptible power system.

6.10.6 Generators

Emergency generator capacity shall be adequate to serve the connected emergency loads. Inrush current of the largest group of motors, automatically started simultaneously, shall be considered. The initial voltage dip shall not exceed 20 percent.

Where an emergency generator must be automatically started and loaded, the 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 emergency generators. Where gas is available, gas turbines may be used.

Emergency generators 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 five days continuous generator operations 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. 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.

6.10.7 Total Energy Systems

The possibility of having a total 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.

6.11 ILLUMINATION

6.11.1 Scope

This section outlines the requirements for illumination of ARS 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 fluorescent lighting fixtures and lighting equipment utilizing energy saving rapid-start, cool-white or warm-white lamps. Ballasts shall be energy efficient, and shall meet UL Class P requirements, equipped with built-in automatic reset thermal protectors. Ballasts shall have a sound rating.

Lighting systems shall be coordinated with building design of aesthetic and decorative effects within the limits of visibility, visual comfort, economics and energy conservation.

Lighting calculations shall adhere to the established procedures of the IES Lighting Handbook and IES recommended practices.

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: switching flexibility; time or photoelectric control; use of high efficiency lighting fixtures and systems; provision of ceiling construction and wiring methods which easily accommodate luminaire relocation; use of building automation systems for switching lights.

6.11.3 Luminaires

Particular effort shall be made to reduce the number of luminaire types in a facility, building, or project, so that the number of spare part replacements required for maintenance shall be kept to an absolute minimum.

6.11.4 Maintenance

Ease of servicing luminaires must be considered in the design process. For lighting fixtures installed in areas where it is difficult and hazardous to relamp fixtures when using ladders, e.g., ceiling fixtures in stairwells, consider using open bottom fixture enclosures that provide access for relamping with a lamp changer.

6.11.5 Grounding

Electrical distribution systems shall be provided with grounded neutral connection. Each voltage level shall be grounded independently. Each voltage grounding point shall be located at the power source. Low voltage systems shall be solidly grounded.

6.11.6 Switches

Local light switch control shall be provided for individual rooms with fixed partitions. 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 relocatable 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. If a building automation system (BAS) is available, it shall be used for switching of lights.

6.11.7 Exterior Lighting

Parking areas, exterior traffic lanes, and pathways to buildings shall be illuminated with luminaires designed for use with high-pressure sodium lamps providing illumination levels shown in IES standards.

6.12 SPECIAL EQUIPMENT

6.12.1 Computer Room Installations

A. Location. Computer rooms shall be located in expandable interior areas to avoid condensation and sun load problems.

B. Electrical Loads:

1) Lighting. Fluorescent 50 foot-candles not exceeding 1.4 watts per square foot.

2) Computer Equipment. Approximately 30 to 40 watts per square foot.

3) Air-Conditioning. Approximately 15 to 20 watts per square foot based on floor-mounted packaged units.

4) Future Expansion. Allow 25 percent spare capacity for feeders and panelboards.

C. Feeders. Each computer area shall be provided with an independent feeder to serve anticipated equipment loads. An independent feeder shall also be provided to serve the air-conditioning system. Each feeder shall have a minimum of two sources and an automatic transfer means or a single source initially with provision for adding a second source. The sources may be two different spot network substations in large buildings or normal power and emergency engine-generator units, depending on the criticality of the computer operation, type of computer equipment, reliability of the normal power source, and availability of funds.

D. Panelboards. Computer and air-conditioning feeders shall terminate in special panelboards within the area. Panelboards shall be provided with remote control switches, etc. to permit disconnecting computer and air-conditioning equipment by master switches described in e, below.

E. Local Power Manual Shutdown. A manual master switch shall be provided at each entrance to the computer area to disconnect power to computer and air-conditioning equipment, but not lighting. Each switch shall be enclosed behind a break glass panel which shall be clearly labeled and provided with key opening for test purposes.

F. Wire Under Raised Floors. Consider the following factors and requirements:

1) Temperature: With air-conditioning down to 55 ^{o}F.

2) Humidity: Up to 95 percent.

3) Current rating of branch circuit conductors: Minimum 125 percent of connected load.

4) Raceways: Extend conduit (magnetic shielding) to weatherproof junction boxes or receptacles. Route conduits clear of, or under, air-conditioning ducts.

5) Avoid use of PVC because dense smoke is produced when it is burned. Also, PVC forms hydrochloric acid (HC1) when combined with water, which may seep into structural concrete and attack reinforcing rods and other structural steel.

G. Wiring Without Raised Floor. Consider floor boxes or underfloor duct for power and controls.

H. Fire Protection. Smoke detection, sprinkler system, or Halon fire extinguishing system shall be installed in accordance with National Fire Codes.

I. Grounding. Include full-size ground conductors with feeders from switchboards and with each branch circuit from computer room panelboard. Ground at least one raised floor support pedestal. Check ground continuity of metallic raised floor elements. Check HVAC air outlets in floors. If metallic, provide ground jumpers to continuous metallic grounded flooring or panel-ground buses.

6.12.2 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. Switchgear assembly, generally an 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 switchgear 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 switchgear 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. Emergency Power for Elevators. When emergency 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.

6.12.3 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.

6.12.4 Lightning Protection

All metal flagpoles and metal stacks either attached to buildings or free standing shall be grounded.

All facilities having a lightning risk assessment index (R) greater than or equal to three determined in accordance with NFPA-78 shall have complete lightning protection systems included in their design. A complete lightning protection system is a system of air terminals, conductors, ground terminals, interconnecting conductors, arresters, and other connectors or fittings required to complete the system.
Facilities having R values less than three shall be evaluated by the design A-E in conjunction with the project EPM with respect to safety, research program, and economic factors to determine the extent of lightning protection required.

6.13 TELECOMMUNICATIONS AND SIGNALING SYSTEMS

6.13.1 Telephone Systems

A. General.

1) Telecommunications distribution facilities shall be integrated early on into the physical construction design plans. The Local Exchange Carrier (LEC) will install, own, and maintain all cable, wiring, and associated terminating hardware (known as the DeMarc) required to provide access to the Public Switched Telephone Network (PSTN). The DeMarc is the point of entry into the facility, which is provided by the LEC by means of underground or overhead cabling (known as outside plant). The inside cables which begin at the DeMarc is a construction design element identified in this and is not provided by the LEC, and include:

a) Conduit

b) Raceways

c) Equipment space

d) Other facilities that are part of the building structure itself.

2) Telecommunications cabling throughout the building should be at a minimum of Category 5E cabling for both voice/data and video. When the building is at a point for telecommunications cabling the current certified technology should be used. In all cases patch panels should be used throughout the telecommunications room and closets to allow for easy cross connections.

B. Service Entrance and Local Telephone Terminations. Telecommunication distribution designs shall fully support LEC facility entrance and termination points within the structure. Additionally, LEC service entrance facilities shall include the provisions as to: the path these facilities follow along governmental property; their entrance point to the building; and their termination point. Discussions with the LEC shall determine, early on, the use of: underground entrances; buried entrances; or aerial entrances. As is the custom of the building owner to provide for the LEC the conduit from the main terminal location or building entrance location to the property line, pole, or manhole, provisions shall be incorporated.

1) Terminating Conduit Inside a Building. Design conduits entering from

"below grade" point shall extend 4 inches above the finished floor. Design conduits entering from a ceiling height shall terminate 4 inches below the finished ceiling.

2) Bonding and Grounding. Bonding and grounding of the telecommunications distribution design shall follow Articles 250 and 800 of the NEC covering general requirements for grounding, bonding, and protecting electrical and communications circuits.

C. Terminating Space for Entrance Facilities. Building space shall be set aside for the termination of entrance facilities and shall provide for: electrically protected; secure; and adequate spacing requirements to meet the building's cable distribution system. Space provided for this purpose therefore shall be: near or at the point where facilities enter the building; be well lighted, providing for a minimum lighting of 30 foot candles, at floor level; environmentally clean; a provided multiple 15 amp duplex-grounded outlets for testing and maintenance; equipped with 3/4-inch fire retardant plywood, securely fastened to supporting walls; and provided access to an approved grounding connection.

D. Equipment Room. Equipment rooms shall be considered distinct from the building entrance facilities insofar as the equipment rooms shall provide for more stringent environmental requirements, and shall house the major components of the building telecommunications system. Three basic system types shall be considered with regard to the building design considerations: central office-based service provided by the LEC, Key Telephone service; and PBX service. In the case of central office-based service, dedicated space will be required to house some equipment, but not as much space required to house Key telephone systems and PBX equipment. Additionally, the larger and more complex the system, the more space shall be made available. (Note: ANSI/TIA/EIA-569-A recommends a minimum Telecommunications Room (TR) size of 3.0 m x 2.1 m (10ft x 7ft). The size of 3 m x 2.4 m (10 ft x 8 ft) will allow a center rack configuration)

1) Environmental Considerations. Environmental requirements shall consider telephone switching system requirements to include: operating temperatures ranging from 32 ^{o}F to 100 ^{o}F; relative humidity ranging from zero to 55 percent; and heat dissipation ranges from 750 BTUs per hour to 5000 BTUs per hour per cabinet.

2) Battery Requirements. Consideration shall be given for UPS requirements, as necessary. Battery floor loading requirements shall vary, depending upon the occupant’s requirements, and can be as low as 100 pounds per square foot to as high as 600 pounds per square foot. PBX UPS shall be governed by NEC, Articles 480 and 503-14, dealing with

code requirements for storage batteries and their associated charging equipment. (Local codes may place more rigorous requirements on storage battery installations.)

3) Lighting Requirements. Lighting fixtures shall not be placed where they will be above the equipment cabinets, the termination frames, or other free standing equipment. Equipment space shall have lighting that provides a uniform light intensity of 30 LM/square foot when taken at floor level.

4) Electrical Requirements. Manufacturer specifications shall guide the basic telephone system(s) electrical requirement. Additionally, PBX installations shall require specialized bonding and grounding of equipment cabinets.

5) Distribution Cable Termination Requirements. Space requirements for distribution cable shall allow for wall mounted terminal fields, free standing frames, or both. For wall mounted terminal field applications, a 3-foot clear work space shall be provided across the entire field.

6) Structural Requirements. Walls of the equipment rooms shall extend from the finished floor to ceiling height and be finished by painting with a minimum two coats of fire retardant paint. Equipment room flooring shall be finished to keep dust to a minimum. Equipment room floor loading requirements shall support equipment cabinets between 50 pounds per square foot to 200 pounds per square foot. Additionally, a minimum ceiling height of 8 feet, 6 inches shall be provided to allow for the adequate clearance of equipment frames for cables and suspended racks.

E. Telephone Closets. Three types of floor closets shall be considered in design specifications. Types shall vary as to the size of the building; number of floors; occupancy characteristics; and telecommunications services to be used. Telephone Closets should be stacked above each other for design and cable flexibility.

1) Doorways shall be designed with a minimum measurement of 3 feet wide by 6 feet, 8 inches high. Measurements shall be exclusive of a door sill or center post. Doors shall be hinged to either open outward, slide side-to-side, or be removable.

2) Floor closets shall be located in areas above the threat of flooding; provided a No. 6 AWG wire from an approved floor ground; and be provided lighting equivalent to a minimum of 30 foot candles measured at floor level. Closets may vary in size depending on their function; however, no closet shall be less than to read 0.6 m deep x 2.6 m wide (2 ft

deep x 8.5 ft wide).

3) All closets shall be lined with a minimum of 3/8 inch thick 8 feet (height) plywood, fastened to the wall framing members; have the plywood painted with fire-resistant paint; and whenever possible, be located on wall space for termination on one continuous wall.

a) Riser Closets. Riser closets shall be used in low, wide buildings where the riser cable is run horizontally, or to provide distribution points on each floor of a multistory building. Riser sleeves/slots shall be provided with a minimum 4-inch diameter; be located on the immediate left side of the closet; be provided 110 VAC duplex power outlets; be fitted with a sufficient number of risers sleeves to accommodate the anticipated needs of the occupant; and be provided lighting equivalent to a minimum of 30 foot candles measured at floor level.

b) Apparatus Closets. Apparatus closets shall provide cross-connect fields for station cables and tie cables to satellite closets, or to house key system controllers and other common equipment that requires commercial AC power. Apparatus closets shall be constructed with a minimum depth of 24 inches, and provide for a minimum of one 110 VAC duplex power outlet which is both separately fused and provides a 20 amp, 3-wire, grounded outlet. (Riser and apparatus closets may be combined.)

c) Satellite Closets. Satellite closets shall provide solely supplemental distribution points for station cables, and shall not provide for key equipment or riser cable distribution. Satellite closets shall be provided with a minimum depth of 24 inches.

F. Conduits. A complete conduit system shall be indicated on the drawings, with routing of main conduits, sizes and locations of pull boxes, and method of termination shown. Minimum conduit size for telephone outlets shall be 1 inch, except that 3/4-inch conduit may be used in buildings having less than 10,000 net square feet of general office space, and for public telephones, telephones in kitchens, snack bars, shops, elevator machine rooms, and electrical or mechanical equipment spaces of similar character. Special isolation and sealing of main panels, conduits, and main distribution lines are required in contained laboratory and animal space. See Chapters 9 and 10.

G. Telephone Rooms. Telephone rooms shall be considered in design specifications. Room size shall vary as to size of building; number of floors; occupancy characteristics; and telecommunication services to be used.

Telephone equipment rooms are considered to be distinct from telecommunications closets because of the nature or complexity of the equipment they contain. Any or all of the functions of a telecommunication closet may be alternatively provided by a telephone equipment room.

Design of a telephone equipment room shall be in accordance with the requirements of the Electronics Industry Association (EIA); Telecommunications Industry Association (TIA) and BICSI specification EIA/TIA-569.

Telephone rooms may be immediately adjacent to or combined with space identified for LEC service entrance and/or terminating facilities. Referenced standards (EIA/TIA-569) identify minimum requirements for square-footage, lighting, atmospheric controls and AC power based upon type and quantity of equipment to be installed.

6.13.2 Fire Alarm Systems

A. Location of Control Console. The control console shall be installed in the engineer's office, 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 may be located in the guard's office with remote indicator in the engineer's office.

B. General Alarm Bells. Where bells are used, they shall be located so that they can be heard in every room. Where partitions prevent distribution of sound, additional bells shall be provided. An alarm bell shall be located above each fire alarm station and at such locations as may be required to assure full coverage.

C. 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 by primary service, the fire alarm power supply shall be taken from the emergency lighting panelboard.

6.13.3 Public Address Systems

Conduit systems to accommodate the public address system equipment shall be provided in each auditorium.

Appendix 6A: Electrical Design Submission Requirements

6A-1. 15 Percent Electrical Design (Concepts) Submittal

A. Drawings

1) Plans showing equipment spaces for all electrical, telecommunication, and security equipment to include: panels; switchboards; transformers; UPS; and generators, etc.

B. Narrative

1) Description of at least three potential electrical systems.

2) Description of the proposed telecommunication/signaling and security systems.

3) Code compliance statement.

6A-2. 35 Percent Electrical Design Submittal

A. Design Analysis

1) Listing of applicable codes and code compliance statement.

2) Lighting calculations

3) Load calculations

4) Life cycle cost analysis of luminaire/lamp system and associated controls

5) 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, 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 each proposed signal system.

e) Description of proposed security systems' features and intended mode of operation. Proposed zone schedule. Proposed card access controls, CCTV assessment and intrusion protection system, if applicable.

f) Proposed Telecommunications Infrastructure. Systems proposed for infrastructure and cabling to accommodate the communications systems. These must be designed and provided in compliance with EIA/ TIA Building Telecommunications Wiring Standards.

6) 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 scheme and locations of electrical closets; major routing of communications system, communications equipment rooms and closets; and plan layouts of electrical rooms showing locations of major equipment.

3) Single line diagrams of the building power distribution system and other signal system including telephones, security, public address, and others.

4) Security system 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.

7) List of specifications sections to be used.

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) Over current coordination study.

7) Generator calculations. Include starter loads.

8) Preliminary equipment selections for major equipment (switchgear, switchboards, motor control centers, panelboards and unit substations, etc.)

9) Responses to the 35 percent Review Comments

B. Drawings and Specifications.

1) Floor plans. Show lighting, power distribution and communications raceway distribution and locations of fire alarm and annunciator panels.

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) Single-line diagrams of telecommunications 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 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.

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

4) 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.

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

1) Complete drawing and specification package suitable to "Issue for Construction."

Appendix 6B: Electrical Design Coordination Checklist

6B-1. General

A. Interference between major conduit and structural framing members coordinated.

B. Adequate clearances to install and service electrical equipment.

C. Light fixture locations and types coordinated with architectural drawings and interior design.

D. Screens for exterior generators and transformers coordinated with architectural drawings.

E. Penetrations through rated walls/floor/roof assemblies detailed and specified.

F. Normal or emergency power supplied for all mechanical and fire safety equipment.

G. Supports and bracing for major conduits and equipment coordinated with structural drawings.

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 exist.

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, Air-Conditioning Engineers, Inc. (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 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 Safetv Staff. 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, 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, 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 for additional information.)

7.2.3 Fume Hood Requirements

All laboratory chemical fume hoods and exhaust systems shall comply with ACGIH 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) and Bypass hoods shall be used in new construction and renovation. (Refer to Chapter 9 for biohazard containment design.)

A. Face velocities shall be 400-600 mm/s (80-120 fpm).

B. Stack heights 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.

C. 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.

D. 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.)

E. 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.

F. Manufacturer Certification. The laboratory hood manufacturer shall provide certification that the unit performs satisfactorily under the condition required by the design documents. ACGIH specifications and procedures for certifying aerodynamic performance of installed fume hoods must be clearly defined in the project specifications.

7.2.4 Fume Hood Exhaust Requirements

Fume hoods will have individual exhausts or up to 8 fume hoods can be manifolded provided a redundant fan for manifolded systems is provided. Fume hoods manifolded shall be analyzed for compatibility. Manifolding of more than 8 fumehoods will require a waiver . See section 7.1.1 for procedures to document a deviation request.

Fume hoods shall be designed to operate on a 24-hour basis. Night set back of fume hood exhaust systems (reduction in output) may be considered to a minimum of 50 percent of occupied mode volume. 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 Laminar Flow Hoods

Only vertical laminar flow biological cabinets shall be used in agency facilities.

Horizontal laminar flow cabinets shall not be installed.

7.2.8 General Purpose Hoods

Hoods for all other purposes shall be designed in accordance with ACGIH

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, vented storage cabinet in accordance with NFPA 30 and NFPA 45.

A. In each laboratory where corrosive materials will be used, there shall be a segregated corrosive material 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.

Note: 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 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 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 or <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 accessability 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 tempered water. The number of water mixing valves to utilize shall be at the option of the A-E.

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 Asbestos

All work involving asbestos-containing materials shall be performed in accordance with OSHA standards contained in 29 CFR Part 1910.1001, as applicable, as well as those Federal and State EPA regulations that pertain to asbestos-containing material maintenance and abatement.

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 (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 system 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. ELEVATORS (VERTICAL TRANSPORTATION SYSTEMS)

8.1 GENERAL

8.1.1 Scope

This Chapter deals with design requirements for elevators or vertical transportation systems for Federal buildings.

8.1.2 Codes and Standards

A. New elevators or vertical transportation equipment installations shall conform to the American Society of Mechanical Engineers (ASME) Safety Code for Elevators and Escalators, A17.1 (herein referred to as the A17.1 Code). 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.

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 Coordination

The elevator 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.

8.2 EQUIPMENT

8.2.1 Passenger Elevators

A. Classification. Passenger elevators; combination passenger and freight elevators; special purpose elevators; and shuttle elevators.

B. Planning. Passenger elevators shall be located so that the building entrances with heaviest traffic will have adequate elevator service.

C. Size and Number. The following factors shall be considered in determining the size and number of passenger elevators required.

D. Cost. The overall annual cost of the elevator facilities, including amortized cost of the original investment, maintenance, material, and consumed power.

E. 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.

F. Population Density. This is the net area per person. Building populations above the main floor shall be estimated on the basis of 135 sq. ft. net area per person.

G. Maximum Traffic Peak. This is the maximum percentage of the total population that shall be handled during any five-minute period. In general, the maximum traffic peak shall be considered as that produced by the morning filling of the building.

H. Traffic Distribution. 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.

I. 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 150 pounds. For office buildings, the most suitable car capacities are from 3,000 to 4,000 pounds. In some instances, larger capacities shall be required. Passenger elevators with capacities less than 2,500 pounds shall not be installed, as they are not suitable for maneuvering a wheelchair. For local service, there is no appreciable saving in time by the use of car speeds exceeding 500 fpm.

For tower office buildings, elevators shall be arranged in a low-rise group, a high-rise group, and possibly intermediate-rise group(s), depending on the height of the building. Each group must include enough elevators to satisfy the requirement for dispatching intervals. Speed shall range from 500 fpm to 2,000 fpm.

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.

Dispatching intervals are classified as follows: 18 to 23 seconds - excellent; 24 to 29 seconds - good; 30 to 35 seconds - fair; 36 seconds and over - poor. Where there are four or more elevators in a group, the dispatch interval shall be in the excellent or good range. Where there are fewer than four elevators in the group, the interval shall be kept to a practical minimum; however, it is recognized that economics may sometimes require acceptance of an interval classed in the fair or poor range. For single elevators and two-car group elevators, the interval shall be much higher, ranging to more than 60 seconds for a single elevator depending on the speed and number of floors served.

J. 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.

K. 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. A combination passenger and freight elevator must have the size and capacity to accommodate the anticipated demand, and generally shall be not less than 4,000 pounds in capacity, preferably larger when hoistway space is available. Door openings shall be not less than 3 feet, 10 inches wide. 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.

L. 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 four stories high), two shall be installed to ensure continuity of service.

M. Future Elevators. The possibility of change in the type of building occupancy and reassignment of building area that would result in a greater volume of passenger traffic shall be investigated. When possibilities exist, the building framing shall be arranged to permit future installation of an additional elevator or escalator equipment to handle future increases in traffic volume.

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.

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.

2) General Freight Elevators.

a) The size of general freight elevators shall be adequate for the movement of essential freight, including relocatable partitions. The platform size shall be not less than 8 feet wide by 12 feet deep. A larger size, adequate far 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.

c) The provision of more than one freight elevator shall be considered in buildings of more than 800,000 gross square feet, when dictated by special known requirements, or by the building design.

D. Capacity and Speed. Freight elevators shall have a minimum capacity of 8,000 pounds, and shall be designed for one of the Class C loadings described in the A17.1 Code. Elevators required to carry loads in excess of 6,000 pounds, or in which heavy trucks shall be used, should have capacities to handle the maximum required loads. Class Cl loading, where trucks are carried, shall be adequate for Federal buildings. 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.

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. Depending on the size and capacity of elevators, provide either intermediate supports between floors or guide rail backing, for larger guide rails where the distance between floors or the structural supports exceeds 14 feet. Provide intermediate supports for elevators with moderately large platforms, large capacity, or those designed for Class C loading when the floor heights are less than 14 feet.

Concrete hoistways or specially designed steel H-column supports for each elevator car guide rail, extending the full height of the hoist way, are required for heavy duty freight elevators designed for Class C loading or one-piece loading. Each project shall be checked to ensure that it includes necessary guide rail supports to conform to the above requirements and to Section 200 of the A17.1 Code. Additional supports for guide rails shall be included as a part of the structural framing of the building.

B. Enclosures

1) Elevator hoist way 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 hoist way and machine rooms.

2) New buildings and nonbearing hoist way enclosure walls of normal height (14 feet maximum unless otherwise noted) enclosing floor openings more than 10 square feet in area shall be stable and have a 2-hour fire rating.

3) For hoist way enclosure walls of abnormal height, check with the structural engineer for stability and possible increases in thickness of material.

4) Hoistway Ventilation. Hoist way 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. (Note: This is rule 100.4 in ASME A17.1 Code).

8.2.4 Elevator Pits

A. Depth Requirements. Pit depths should comply with the A17.1 Code requirements. Freight elevators, which have counterbalancing vertical sliding doors at the lowest landing, shall have a pit depth of not less than half the height of the door plus 6 inches to accommodate the lower floor panel.

B. Access (Rule 106.1d, A17.1)

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. 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.

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. 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. 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) Openings in the floor for passage of moving ropes, etc. shall have 2-inch-high concrete curbs or extended metal sleeves.

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. <u>Provisions for Removal of Equipment</u>

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. <u>Access</u>: (Rule 101.3, A17.1 Code)

1) <u>Entrance Door</u>. 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.

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 shall be located as far as possible from them.

2) Vibration and Sound Isolation. Geared machines and motor generator sets shall be mounted on vibration and sound isolating devices.

3) Skylights. Skylights shall not be installed in elevator rooms.

4) Heating. Heating shall be provided in elevator machine rooms as required.

5) Ventilation. Machine rooms shall be provided with ventilation as to limit space temperature rise to 10 ^{o}F.

8.2.6 Escalators

A. Planning. When vertical transportation is required for a large volume of traffic, escalators shall be installed 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. Location. 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. Where escalators serve three or more floors, they shall not be installed where the structure depth encroaches on the clearance of the ceiling height below.

C. Comparison with Elevators. One escalator provides circulation at any one time in only one direction and only to one additional floor, while an elevator provides service in both directions to all floors. Most individuals with physical disabilities cannot safely use an escalator. Two escalators are needed for two-way traffic, i.e., four escalators are required to serve three floors for two-way traffic. When considering whether to use escalators in a building, the overall annual cost of providing the required service with elevators shall be compared, and use most economical arrangement selected.

D. Size and Number

1) Escalators shall have a width of 32 inches or 48 inches with an angle of inclination of 30 degrees and tread speed of 90 fpm. The capacity rating shall be 5,000 persons per hour based on a theoretical maximum loading of 1-1/4 persons per 32-inch tread or 8,000 persons per hour with two persons per 48-inch tread.

2) The actual design capacities in persons per hour and in persons per 5 minutes traffic peak to be used in estimating escalator requirements is as follows

Escalator Width	Capacity in Persons/Hour	Capacity in Persons/5 Min
32 inches	3,000	250
48 inches	4,800	400

3) In determining the size and number of escalators, passenger elevators shall be considered to ensure proper quantity of service required to handle maximum peak.

4) When escalators are provided for special purposes, to serve auditoriums and cafeterias, the number and size shall be based on estimated peak movement of traffic determined from similar existing installations.

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. <u>Size and Number</u>. 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. <u>Capacity and Speed</u>. 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. <u>Types</u>. Dumbwaiters shall be of the power-operated type.

F. <u>Hoistways</u>

1) <u>Enclosures</u>. Dumbwaiter hoistway enclosures shall be of fire-resistant construction with a smooth interior finish.

2) <u>Entrance Doors</u>. 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 dumbwaiters. 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) <u>Size and Clearance</u>. 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) <u>Machine Spaces</u>. 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.

8.2.8 Wheelchair Lifts

A. Classification. Vertical wheelchair lift or inclined wheelchair lift.

1) 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.

B. 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.

C. Vertical Wheelchair Lift Performance. Maximum rise shall not exceed 6 feet. Capacity shall be 450 pounds. Maximum speed shall be 30 fpm.

D. 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.

E. 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.

8.2.9 Exterior Power Platforms

A. Planning. Exterior power platforms, for window washing and for other maintenance, shall be determined on an individual project basis.

B. 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.

C. 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.

D. 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 overturnings. 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.

E. <u>Coordination</u>. 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.

This page will be reserved for Dr. Kiley's Preamble for Chapter 9.

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 Nonindigenous, 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)

1) See the web site "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. Biosafety Level 1 (BSL-1). 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. Biosafety Level 2 (BSL-2). 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. Biosafety Level 3 (BSL-3). 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 can not 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) Safety equipment includes biological safety cabinets and autoclaves.

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.

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 an 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-doored 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	recommend ed*	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	recommend ed	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 Cleaning	cages washed, then rinsed at 180 degrees.	cages washed, then rinsed at 180 degrees.	cages washed, then rinsed at 180 degrees.	required	required
8. Appropriate Cautionary Signs	n/a	required	required	required	required

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
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 or 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 to Water, Resistant to Acids, Alkalis, Organic Solvents and Moderate Heat.	required	required	required	required	seamless required

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
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 recommend ed 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**): 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)*	ducted exhaust required	ducted exhaust required	ducted exhaust required	required	required

Biosafety Levels:	BSL-1	BSL-2	BSL-3	BSL-3 Ag	BSL-4
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. <u>Ventilation (Containment Equipment)</u>: 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
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, welded ductwork.	BSC, HEPA filter assemblies, containment room, 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 trowled 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 an 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.

<u>Gas-tight ductwork</u>. 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.

<u>Air filtration</u>. 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, “N+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 ½" 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 ½ x 11 inch paper which includes the following:

1) Copies of all correspondence related 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 electrical systems and emergency back-up.

h) Description or diagram of methods proposed to seal barrier penetrations.

i) Description of proposed testing methods for rooms, ductwork, HEPA filter 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 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 to accomplish 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 are 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.

Approved Testing Procedure:

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 10 percent of the design air flow rate of the filter. Place the PAO generator to uniformly introduce PAO aerosol upstream of the HEPA filter. Measure and record the upstream PAO concentration approximately in the center of the filter face.

For linear readout photometers (graduated 0–100), 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 2 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 ½ 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. Pretesting

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 ½ 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 ½ 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.

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.

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).

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 CFC 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 interior surfaces of all ducts, seams, joints, gaskets, and other areas of possible leakage at a distance of 1/4 to ½ 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 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 or 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.

Insect Vector. Any insect capable of transmitting a pathogen from one host to another.

Laminar Flow. 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.

Magnahelic Gauge. 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.

Mask. See "Respirator."

Mask Air. Piped supply of conditioned air for ventilated personnel suits and hoods. See also "Ventilated Suit."

Non-Biohazard Area. An area with definite boundaries designed to be free of harmful microorganisms. See also "Clean."

Microorganisms. In this chapter, when not qualified, refers to infectious microorganisms.

Non-Biohazard Change Room. See "Clean Change Room."

PAO. The abbreviation for polyalphaolefin which is aspirated into "smoke" for testing HEPA filters and assemblies.

Pass Box. 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."

Pasteurization. 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.

Peracetic Acid. One of the compounds used for disinfecting the one-piece, positive pressure, protective suits.

Peracetic Shower. See "Disinfectant Shower."

Personal Assistance Alarm. 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, 1985 (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).

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 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.

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 8 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 °F and 84 °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 conditions 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.