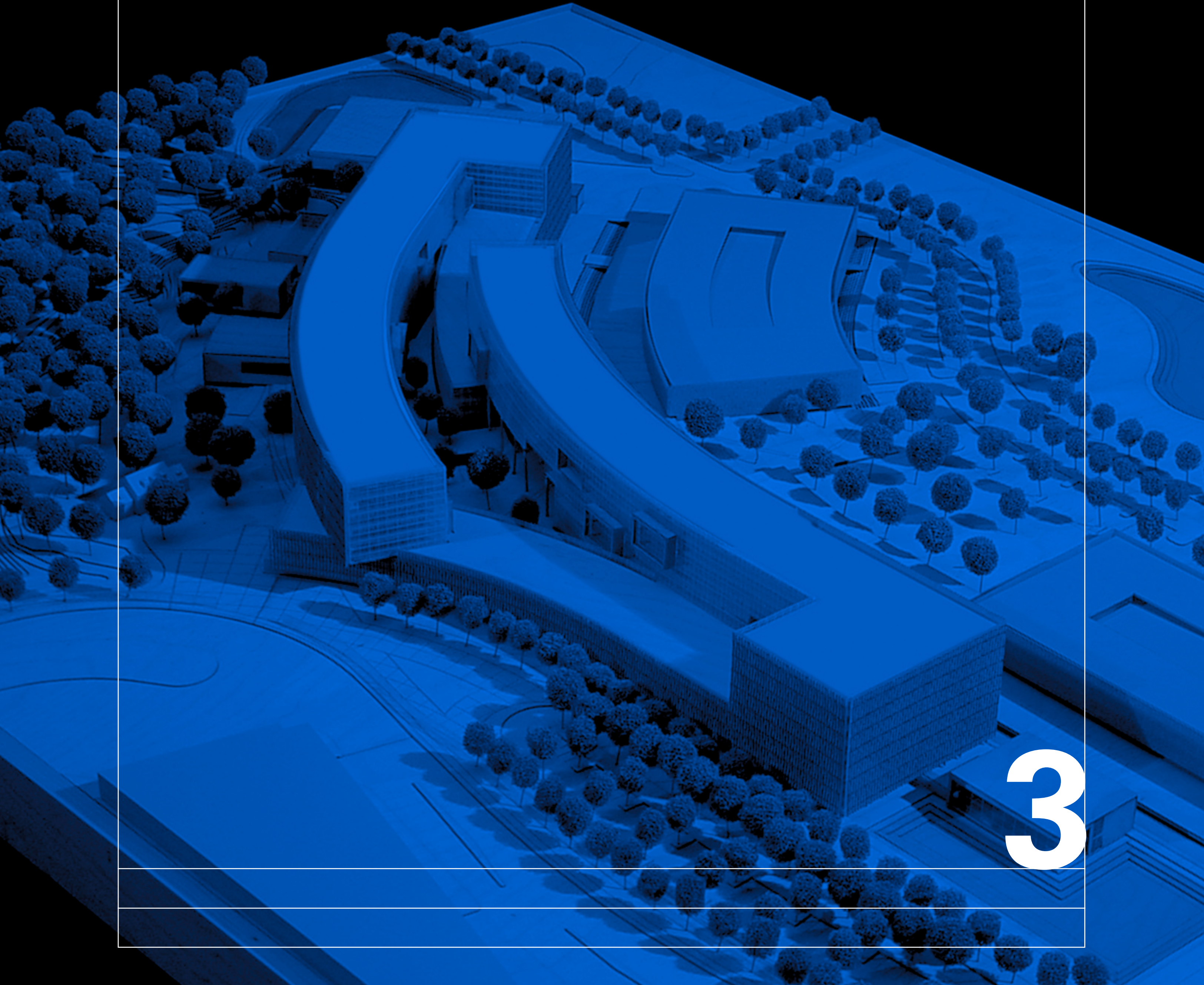
Architectural and Interior Design



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3.1 Basic Building Planning Principles

Integrated Design. Landscape and Architectural designs must be integrated with all project design disciplines in order to optimize building performance and aesthetics. Prior to initiating any schematic design, the Architect must perform a series of coordination meetings with all project design disciplines/consultants to explore performance and functional objectives that could impact building orientation, massing, space adjacencies, material selections, and assemblies. A project's functional and performance needs are integral to achieving the Principles of Federal Architecture, noted in Chapter 1.

Performance Measures and Functional Objectives. The A/E shall ensure the design supports quality based performance measures for customer satisfaction, energy consumption, and reduced operations and maintenance. The A/E shall also identify all functional expectations and establish alternative features that support attainment. To the maximum extent possible, the A/E shall apply those architectural elements that optimize building performance and functional capabilities. Performance and functional issues raised in the project's design program and/or as addressed in Appendix A.2 shall be specifically addressed in concept presentations.

Environmental Sensitivity. The natural setting of the site, its contours and vegetation shall be viewed as assets to be preserved and woven into the design as much as possible. In settings including historic buildings, adjoining historic properties, or located near historic properties that will be affected by GSA construction, external design review, including public participation, is required under the Section 106 of the National Historic Preservation Act and may also be required under the National Environmental Policy Act. Compliance reviews should be coordinated, through the Regional Historic Preservation Officer, early and as frequently as the project complexity warrants, so that comments can be effectively addressed during the course of design.

Urban Context. Facility design and orientation should be consistent with existing and planned development patterns and nearby uses. The building's exterior should be consistent with existing local design guidelines. Where appropriate, the project team should help to develop design guidelines for the project and neighboring undeveloped sites.

Basic Configurations and Core Placement. Planning for cores must consider the depth of the occupiable space established by the core and exterior walls. The optimum depth of the occupiable space (the space between core and window wall) in an office building is approximately 12,000 mm (40 feet) for providing access to daylight.

Placement of Core Elements and Distances. In buildings with large floor plates, not all core elements need to be placed at each core location. How often each element needs to be repeated is governed by occupant needs and the following maximum radii and distances:

- **Passenger Elevators** should be grouped in banks of at least two for efficiency. Elevator groups of four or more should be separated into two banks opposite each other for maximum efficiency in passenger loading and minimum hall call notification for accessibility under requirements of UFAS/ADA. Travel distances from a given office or workstation to an elevator should not exceed 61 000 mm (200 feet).
- See Chapter 7: *Fire Protection Engineering* for additional egress requirements.

Table 3-1
System Placement in Planning Grid

Element	Relationship to Planning Grid	Comments
Planning Grid	600 mm by 600 mm (2-foot by 2-foot)	Uniform between buildings allows interchange of parts between GSA buildings.
Exterior Window Mullions	align on grid	Allows interior partitions to terminate on mullions and ceiling grids to align visually with the mullions.
Columns	center on grid	
Partitions	center on grid can be aligned on face of columns	Normally split columns between two separate offices.
Trench Ducts	offset by up to 50 percent	Allow access to trenches without walls being placed along trenches.
Raised Floor Grid	offset pedestals by a minimum of 75 mm (3 inches) in both directions	Facilitate future removal of floor panels and to avoid excessive cutting of panels in instances where partitions must extend to the structural slab.
Cellular Floor Insets	Offset from grid in both directions, placed every 1800 mm (6 feet) in both directions	Placed between grids so they are never covered by partitions.
Floor Outlets for power, telephone and data	Offset from grid in both directions so centerline of the three may fall a minimum of 300 mm (1 foot) off the planning grid line	Placed between grids so they are never covered by partitions.
Ceiling Systems	Align, or offset by 300 mm (1 foot) or 50 percent in both directions	If aligned with grid, ceiling will visually align with window mullions. If offset by 50%, tops of walls will never fall on ceiling grids, allowing more choice in placement of ceiling elements such as lights.
Lay-In Lights	In ceiling grid	For 600 mm by 600 mm (2-foot by 2-foot) or 600 mm by 1200 mm (2-foot by 4-foot) fixtures.
Downlights and Pendant Mounted Lights	In ceiling grid	
HVAC Diffusers & Return Air Grilles	Staggered, located within the 600 mm by 600 mm (2-foot by 2-foot) ceiling framing	Experience has shown that a staggered diffuser layout in a uniform pattern adapts most easily to future changes in wall configurations
HVAC Slot Diffusers	Placed on grid line	

- The location of stairs within buildings should encourage their use, in lieu of elevators, to the fullest extent feasible. This will reinforce the recognition of sustainable energy conservation.
- **Electrical Closets** must be stacked vertically and should be located so that they are no more than 45m (150 feet) from any occupied space. Shallow, secondary closets off permanent corridors may be used for receptacle panelboards where the distance between the riser and the farthest workstation exceeds 45 000 mm (150 feet) and a separate riser is not warranted. See section *Space Planning, Building Support Spaces, Mechanical and Electrical Rooms* of this chapter for minimum size requirements.
- **Communications Closets** shall meet the requirements of EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins). Communications closets must be provided on each floor, with additional closet for each 930 m2 (10,000 square feet). Closets must be stacked vertically and must be placed so that wiring runs do not exceed 90 m (300 feet). Closets must tie into vertical telecommunications backbones. See section *Space Planning, Building Support Spaces, Mechanical and Electrical Rooms* of this chapter for minimum size requirements.

Building Circulation
Federal buildings must have clear circulation systems.

Utility system backbone pathways should be routed in circulation spines providing service access to utilities without disrupting other tenant agencies.

Planning Grid
Planning grids shall be used to integrate building interiors to allow more future serviceability, particularly for buildings that will experience extensive reconfiguration through their life span. A building design shall follow the prescribed planning grid dimension unless the designer can show long term efficiencies using another dimension. Following a standard dimension will allow GSA to maintain standard replacement parts to service the building.

Some structural bay sizes can adversely affect interior parking layout. The 6100 mm by 6100 mm (20-foot by 20-foot) bay is too narrow for a two-way driveway aisle. Some of the larger bays cannot be efficiently adapted to parking layouts. Transfer beams or inclined columns would have to be used to adjust the column spacing. If a major parking facility must be integrated with the office structure, the 9100 mm by 9100 mm (30-foot by 30-foot) bay is recommended.

Technology Infrastructure
A total integration of all building systems will provide for current operations as well as for future changes. A technology infrastructure should be planned in each building to accommodate power systems including normal, emergency and uninterrupted power, mechanical systems and controls, fire detection and suppression systems, security systems, video and television systems, communications systems, including voice and data, lighting controls, plumbing services, and special utility services, such as gas or exhaust systems. It is not intended to provide infinite amounts of space for these systems, but to recognize their dimensional characteristics and the ability to service system components. The infrastructure must provide adequate spare capacity and integrate the utility entrance facilities, equipment rooms, backbone pathways, horizontal distribution pathways and workstation outlets for each system. In part, floor-to-floor heights are determined by the depth of space required for the technology infrastructure, including structural, mechanical, electrical and communications systems.

Four key concepts must be followed in providing technology infrastructure in Federal buildings.

- Equipment rooms and closets should be located together on each floor.
- All walls of equipment rooms and closets should be stacked vertically using the same plan configuration from floor to floor to accommodate vertical risers for backbone systems. When more than one closet is required on each floor, they shall be interconnected by a minimum of two 100 mm (8 inch) conduit passageways.
- Accessible flexible horizontal pathways must be provided from the closets on each floor to the workstation outlets. These pathways may be through underfloor ducts, cellular floor systems, access floor systems, or overhead cable trays and wire ways. Horizontal pathways must provide at least three separate channels for separation of power and different communications systems.
- Excess capacity must be provided in each system for future expansion of services.
- The data/telecommunications closet must be adequately sized to accommodate multiple vendor equipment and for the ease of maintenance of the equipment.

EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins) provides specific criteria for infrastructure for communication systems. The criteria covers the communication service entrance pathway, entry point, entrance room, equipment room, vertical backbone pathway, communication closets, and horizontal pathways. Horizontal pathways covered by this standard include underfloor duct, access floor, conduit, cable trays and wire ways, ceiling pathways and perimeter pathways.

Horizontal Pathway Systems. Three options exist for delivering power and communications to general office areas: raised access floor, cellular floor duct, and underfloor duct encased in concrete deck. After decades of experience with moves and changes within Federal office space, GSA now provides a general life cycle cost study to determine which of these three options should be used. See Chapter 6: *Electrical Engineering, Placing Electrical Systems in Buildings, Horizontal Distribution of Power and Communications*.

Access Floors. Access floors shall be incorporated into all new construction where office functions will take place. Permanent corridors can be exempted from this requirement.

The vertical zoning of the floor-to-floor space for horizontal utility distribution must be analyzed. In typical office areas, this can be standardized. In special purpose spaces such as courtrooms, meeting rooms, library stacks, or laboratory spaces, the infrastructure must be given detailed consideration before establishing the final floor-to-floor heights.

Floor Air Plenum distribution systems are preferred in office applications with raised floors, eliminating ceiling ductwork and facilitating personal climate control systems. If this technology is considered, then the interstitial floor height shall be adjusted to accommodate the HVAC system.

All underfloor and ceiling areas used for horizontal system distribution must be accessible without requiring repair to interior finishes. To the extent possible, avoid routing pathways over areas where it is difficult to bring in hoist or set up scaffolding, such as fixed seating areas and sloped or terraced floors for stairways.

Space Allocations and Classifications

This section describes the methodology and policies for tabulating space requirements for GSA facilities. It also describes application of GSA policies for providing and charging tenant agencies for space in GSA-owned or -controlled space.

The GSA provides space for Federal agencies and charges the agencies a rental rate for the space they utilize. Therefore, GSA tabulates space for both planning purposes and for charging rent. These two purposes require slightly different application of the same space measurement information. For planning purposes, GSA converts agency space requirements, expressed as usable area, to gross building area through the application of building efficiency factors. For rental charges, GSA converts the agency space requirements, expressed as usable area, to rentable area through the application of ratios that are unique to each building. Agencies identify the amount of usable area they require within a building for the GSA and request this space on a Standard Form 81 (SF81).

GSA provides a tenant improvement allowance for finishes and features within its rental charge. The A/E must design within that allowance. The agency may fund any costs over the tenant improvement allowance directly through a Reimbursable Work Authorization (RWA).

The GSA uses formalized standards for establishing the area to be allocated to each tenant agency for the rent charge. GSA has adopted the Standard Method for Measuring Floor Area in Office Buildings ANSI/BOMA Z65.1, current edition, issued by the Building Owners and Managers Association (BOMA). This standard is a national standard approved by the American National Standards Institute. The full standard is available from BOMA International.

Certain systems related to security monitoring and building control may be provided as part of the project by GSA, or, if specially requested, by the tenant agencies, with GSA providing the infrastructure support.

Space Measurement for Rental Purposes

A Summary. The following are terms and calculation formulas extracted from the ANSI/BOMA Z65.1. They are provided to assist the user in understanding GSA's space accounting. Individuals responsible for performing space measures must utilize the entire Standard Method for Measuring Floor Area published by BOMA.

The ANSI/BOMA Z65.1 standard uses a two-step process to determine rentable area assessed a tenant. The first step allocates common shared space on each floor to the tenants of that floor. The second step allocates common spaces that support the entire building to all tenants within the building. This explains the use of different ratios for each floor.

Basic Rentable Area. Basic rentable area is the usable area occupied by a tenant plus their proportion of the floor common areas. It is calculated by:

Usable Area x Floor R/U Ratio = Basic Rentable Area

Building Common Area. Building common area is usable area allocated to provide services to building tenants but is not included inside a tenant space. Building common areas include lobbies, atrium floor space, concierge areas, security desks located in public areas, conference rooms, lounges or vending areas, food service facilities, health or fitness centers, daycare facilities, locker or shower facilities, mail rooms, fire control rooms, fully enclosed courtyards, and building core and service areas such as mechanical or equipment rooms. Excluded from building common areas are floor common areas, parking spaces and loading dock areas outside the building line.

Building R/U Ratio. Building R/U ratio is the factor used to distribute building common areas to all tenants on a prorated basis. Note that this figure will be constant for the entire building, but could change over time if portions of the ground floor are converted from common areas to store areas.

Building Rentable Area. Building rentable area is the sum of the floor rentable areas. It is also equal to the gross measured area of the building minus vertical penetrations.

Floor Common Area. Floor common area includes toilets/washrooms, janitorial closets, electrical rooms, telephone rooms, mechanical rooms, elevator lobbies, and public corridors that are available primarily for the joint use on that floor. Note that this will vary floor to floor based on public corridor configurations. For single-tenant floors, corridor and lobby spaces may be included in the office or store usable area because they will be for the exclusive use of that floor's only. On main ground floors, floor common areas would only include corridors created because of store area configuration and telephone, janitor closet and electrical closets added because of the addition of store area on the ground floor.

Floor R/U Ratio. Floor R/U ratio gives the basic rentable area. It is calculated by the following formula:

Floor Rentable Area/Floor Usable Area = Floor R/U Ratio

Note that this ratio will vary from floor to floor based on public corridor configurations.

Oakland Federal Building, Oakland, CA

Floor Rentable Area. Floor rentable area is the gross measured area minus the exterior wall and major vertical penetrations. Floor rentable area is calculated by:

(sum of Office and Store Usable Areas on the floor) x Floor R/U Ratio = Floor Rentable Area

It is also equal to the sum of the basic rentable areas for that floor. Full floor tenants will be assessed the gross measured area of a floor *minus building common spaces* as their floor rentable area. Note that because it includes building common area, floor rentable area is not necessarily indicative of space demised for a single tenant's use.

Floor Usable Area. Floor usable area is the sum of all office, store and building common usable areas. Floor usable area is the floor rentable area minus floor common areas which are available primarily for the joint use of tenants on that floor.

Gross Building Area or Constructed Area. Gross building area or constructed area is the total constructed area of a building. This is the area GSA budgets for construction purposes.

Gross Measured Area. Gross measured area is the total area within the building, minus the exterior wall.

Office Area. Office area is the usable area within the tenant space including internal partitions and half of the demising wall separating the space from other tenants. It is measured to the tenant side finished face of all building common areas.

R/U Ratio. R/U ratio is the factor used to convert usable area to rentable area. It is the product of the Floor R/U ratio and the Building R/U ratio. It is derived by the following formula:

Floor R/U Ratio x Building R/U Ratio = R/U Ratio

It accounts for the allocation of floor common areas and building common areas. Note that it will be different for each floor.

Rentable Area. This is the figure that will be assessed each tenant for their space charges. Rentable area includes the usable area, the prorated share of the floor common area, and the prorated share of the building common areas. It is calculated by the following formula:

Usable Area x R/U Ratio = Rentable Area

It may also be calculated by the following two-step formula:
Step 1)

Usable Area x Floor R/U Ratio = Basic Rentable Area

then Step 2)

Basic Rentable Area x Building R/U Ratio = Rentable Area

Store Area. Store area is the usable area of a structure that is directly served by permanent public lobbies or has direct access from outside. BOMA describes these spaces as suitable for retail occupancies. The term store area was developed for main ground levels to allow the public lobby and other building common areas to be prorated to all tenant spaces in the building measured in m^2. Most common space on main ground levels normally falls within building common areas rather than floor common areas, so rentable figures for store areas will not normally be significantly impacted by floor common areas.

Usable Area. Usable area is the actual area the agency occupies in a tenant suite measured in square meters. It is the office area, store area or building common area. It is calculated by measuring from the dominant portion of the exterior wall to the outside face of major vertical penetrations. It includes all structural elements, openings for vertical cables, and vertical penetrations built for the private use of the tenant.

Space Measurement for Planning Purposes

Tenant agencies communicate their space requirements to GSA on the Standard Form 81 (SF81). This form identifies the total area of each space classification required by the agency within an individual building.

Tabulation of space requirements for planning purposes involves four steps:

Step 1 – Tenant agencies must identify the individual room areas they require within a facility or tenant suite.

Step 2 – To calculate the total usable area within an agency's suite, additional area must be added to the individual room areas to account for internal corridors, partitions, structural members, and planning inefficiencies. Traditionally, GSA has instructed the tenants to include 50 percent of an aisle space directly fronting the individual room area and the partitions enclosing the room area as part of the room area request. GSA then has added to this a factor of 20 percent to convert individual room areas to agency usable area. GSA must report the utilization of space by tenant agencies to the Office of Management and Budget. Target utilization ratios include 3.25 m^2 (135 square feet) for primary office space with 20 percent additional space for office support areas. The agency may also calculate the usable area from the individual room areas by directly multiplying the area enclosed in the room by a factor. The following minimum planning factors are recommended. For spaces requiring wider aisles or more than one or two cross-aisles, or in buildings with irregular column grids, curved or stepped external walls or odd-shaped floor plans, higher planning factors are recommended.

Rooms size	Factor
Less than 10 m^2 (100 sf)	1.4
Less than 15 m^2 (150 sf)	1.3
Less than 50 m^2 (500 sf)	1.2
Less than 100 m^2 (1000 sf)	1.1

Step 3 – Classify space according to the GSA space classification standards, and request space from GSA on the SF81. GSA must have a signed SF81 from the tenant agency to process a space request.

Step 4 – GSA divides the sum of the tenant usable space areas to be housed in the building by a building efficiency factor to convert the usable area tabulations to a gross building area. The gross building area is the size of building Congress will fund. Efficiency factors used by GSA for planning purposes include the following:

Facility Type	Planning Factor
Warehouse	85%
Libraries	77%
Office	75%
Courthouse	67%

The space classification system is divided into general broad categories with subcategories for specialized spaces. The following are classifications currently used by GSA for planning purposes.

Space Classification

1. Office	Total Office
2. Other General Purpose	ADP, auditorium, light industrial, structurally changed, lab, conference/ training, food service, cafeteria, snack bar, health unit, fitness center, judges chambers, childcare
3. General Storage	general storage
4. Tenant floor cut	TFC
5. Residence & Quarters	quarters and residence
6. Outlease Retail	
7. Courtroom	judicial hearing rooms, courtrooms
8. Non-Building Charges	railroad crossing, antennas, boat dock, land

(square footages associated with this category, if they exist, fall outside the ANSI/BOMA total, and the "Assigned" total)

Conveying Systems

All elevators must be designed to comply with ASME A17.1 and with the UFAS/ADA *Accessibility Guidelines*.

All occupied areas of a GSA multi-story building or facility must be served by at least one passenger elevator. Areas of future expansion must be anticipated as well as future configuration of existing spaces, to ensure all areas are provided elevator service in the future.

The ASME A17.1 current edition applies to the design of all elevators, lifts and escalators. Additionally, UFAS/ADA *Accessibility Guidelines* must be complied with for accessibility.

The selection of type and quantity of conveying systems, such as elevators, escalators and wheelchair lifts, must be made in conjunction with a thorough vertical transportation traffic analysis of the facility.

Elevators. If no separate freight or service elevator is provided, one passenger elevator must be designated as a service elevator with pads to protect the interior wall surfaces of the cab. A minimum ceiling height of 2700 mm (9 feet) is required in service elevator cabs. Freight elevators shall have a ceiling height of not less than 3700 mm (12 feet).

In large or high-rise buildings, the number of freight elevators provided for GSA buildings should be determined by the elevator traffic analysis. The use of more than one freight elevator will provide better freight service for the tenants as well as provide redundancy for normal maintenance and during times when repair work is conducted.

Where equipment penthouses are provided, service elevators should provide access to that level.

There may be *Security or specific purpose* elevators to transport designated groups of people such as judges, cabinet members or prisoners.

Lockout should be provided for all floors served by passenger and freight elevators. Key locks, card readers or coded key pads, integral with the elevator control panel, must be provided to override lockout. A non-proprietary elevator control system should be used. The extent of control should be defined by the GSA Project Manager. See Chapter 8, *Security Design*.

Trap doors and hoist beams shall be provided at the elevator machine rooms for traction elevators where the machine room is not served by a freight or service elevator for removal of equipment for service and repair.

Elevator Traffic Analysis. The A/E must hire an independent consultant to perform objective studies on the number and type of elevators needed at the facility. The traffic analysis shall determine the quantity, capacity and speed requirements of elevators. The capacity and speed are the limiting factors used in determining the minimum number of cars that will meet both the average interval and handling capacity criteria.

Separate calculations must be made for passenger and for freight or service (combination of passenger and freight) traffic. If there are parking levels in the building, a separate analysis should be prepared for the shuttle elevators connecting parking levels with the lobby.

The type of building occupancy will determine the probable number of stops used in the traffic analysis calculations. A single-tenant building will require a greater probable number of stops than a multi-tenant building. This is especially true when balanced two-way traffic is considered because the incidence of inter-floor traffic is much greater in a single-tenant building.

The anticipated elevator population shall be calculated based on the occupiable floor area of the building and a factor of 14 m^2 (150 ft^2) per person. It shall be assumed that 8 to 10 percent of the resulting population would not require elevator service during the peak periods. If the building design requires two or more elevator banks, the population calculation results shall be apportioned by functional layout of the building. These divisions shall then be assigned to the appropriate elevator banks. For this purpose an "elevator bank" is defined as a group of adjacent or opposite elevators that function under a common operational system.

The criteria by which the traffic analysis calculations should be judged are "average interval" and "handling capacity."

Average interval is defined as the calculated time between departures of elevators from the main lobby during the a.m. up-peak period. Calculated intervals during the up-peak period should not exceed 30 seconds for a typical elevator bank.

Handling capacity is defined as the number of persons the elevator system must move in any given 5-minute period of up-peak traffic used to measure average interval. GSA buildings shall always be designed for a 16 percent handling capacity, even if the building is designed as a multi-tenant facility.

Elevator Capacities. Capacities of 1590 kg to 1810 kg (3,500 to 4,000 pounds) shall be used for passenger elevators. Elevator cab sizes shall be in accordance with the standards established by the National Elevator Industries, Inc. (NEII). Elevator cabs shall be designed to reflect the architectural character of the building design.

Escalators. Escalators may be installed as supplements to elevators when vertical transportation is required for a large *unpredictable* volume of public traffic. GSA prefers to use escalators only where absolutely necessary because of high maintenance costs. They should be used where the first floor is not large enough to contain the high public traffic so that the interval for elevators can be calculated with accuracy.

Escalators should be located to be visible from the building entry and convenient to the areas they serve.

Table 3-2
Criteria for Design of Escalators

Nominal Escalator Width	Capacity in Persons Per Hour	Capacity in Persons Per 5 Mins.
820 mm (32 in.)	3,000	250
1200 mm (48 in.)	4,000	400

Fire Protection

See Chapter 2: *Site Planning and Landscape Design* and Chapter 7: *Fire Protection Engineering* for additional requirements.

Seismic Design

Seismic design is discussed in detail in Chapter 4: *Structural Engineering*.

Design Issues Affecting Security

Specific criteria for site and building security are described in detail in Chapter 8. Some of the planning concepts are stated here because of their importance to building planning, but architects should familiarize themselves with Chapter 8 before developing schematic design concepts.

General Layout. Many future security problems can be prevented by planning a clear, simple circulation system that is easy for staff and visitors to understand. Avoid mazes of hallways and hidden corners. Exterior doors should be readily visible.

Planning for Future Security Provisions. All Federal buildings shall be planned to allow for future controlled access, both to the entire building and to individual floors.

Site Design. Building entrances shall be designed to make it impossible for cars to drive up and into the lobby. Planters can be provided as barriers; bollards are also acceptable if well integrated with the design of the building entrance. Barriers to vehicle access should be visually punctuated and as unobtrusive as possible to pedestrians. Consideration should be given to incorporating security features that allow for flexible use of the site. If addressed skillfully, planters, trees, or sculpted bollards can be employed to provide amenities while meeting vehicle barrier requirements. High blank wall should be avoided; lower walls with sitting edges are preferable.

Building Entrances. GSA buildings should have *one* main entrance for staff, visitors and the public. In large buildings a second entrance may be designated for employees only. Buildings may have additional doors used for egress or access to service areas. These doors should not be used as entrances. Original primary entrances at historic buildings should be retained as such. Closure of ceremonial entrances and redirecting public access to below grade and other secondary entrances for security or accessibility purposes is discouraged. Wherever possible, access for the disabled to historic buildings should be provided at, or nearby original ceremonial entrances. See Chapter 8 for access controls and intrusion detection systems.

Building Lobby. The building lobby shall always be designed to permit subdivision into a secure and a non-secure area. The two areas could potentially be divided by turnstiles, metal detectors or other devices used to control access to secure areas. There shall be space on the secure side for a control desk and an area where bags can be checked. Mechanical ductwork, piping and main electrical conduit runs should not extend from one area to the other. In building entrance lobbies, vending machines, automatic tellers, bulletin boards, and other tenant support services should be located in ancillary space outside of entrance lobbies or consolidated in a retail tenant service core. Equipment that must be installed in lobbies should be of a low profile variety and consolidated with other equipment to minimize bulk.See the section *Space Planning, Public Spaces, Entrance Lobby and Atria* of this chapter.

Lobby Security Equipment. The A/E shall incorporate non-prescription screening devices into the lobby entrance design. In historic building entrance lobbies, where feasible, security processing equipment should be located in an ancillary space. Equipment that must be installed in historic lobbies should be of a low profile variety, consolidated with other equipment to minimize bulk, and placed carefully to avoid altering the original spatial configuration of the lobby. See First Impressions Program.

Courts and Plazas. The most important consideration in designing exterior plazas and public spaces is the future potential use of those spaces. Potential uses should include shared and alternate uses. The team should discuss with potential users how they would like to use the space, in order to incorporate appropriate amenities, relate outdoor areas to inside uses (e.g., like dining facilities), accommodate traffic to and from the building, and provide for regular programmed use of the spaces and special events, as appropriate. Consideration should be given to different areas of a public plaza which would be appropriate for different types and intensities of public activity. Potential users of the space would include not only the building tenants, but also persons in neighboring properties as well as organizations, such as performing arts or vending organizations, that might assist GSA in bringing activities into the space. The treatment of seating, shade, water, art, bollards, and the space's flexibility are important to supporting appropriate uses.

Plazas should be designed with electrical outlets, and other simple infrastructure, to support future flexibility and a wide range of uses.

U.S. Courthouse, Boston, MA

Retail Shops. Generally, retail shops should be located on the non-secure side of the lobby. Exceptions could exist where commercial establishments serve the building population only. Some buildings may have multiple levels of retail around an atrium. In that case, the security checkpoint should be located at the elevator lobby. Designers should coordinate opportunities for retail with the Retail Tenant Services Center of Expertise as well as the Center for Urban Development.

Elevators. See *Building Planning, Conveying Systems* section of this chapter and Chapter 8. Elevator control panels must have lockout provisions for all floors (passenger and freight).

Mechanical and Electrical Spaces. Access to mechanical and electrical spaces should be from the inside of the building, located on the secure side of the (potential) security point in the building lobby.

3.2 Space Planning

Closed Offices Versus Open Plan. The open plan approach (with a very limited number of ceiling height partitions for offices) is encouraged. It has a higher degree of efficiency and flexibility, and provides easier distribution of natural light and daylighting techniques, heating and cooling to the working areas. This approach can be adapted to a larger building depth and still present an open and airy atmosphere. It also encourages interaction between individuals and work groups.

Ceiling Height. Above all, the general office space should have a uniform ceiling height to provide flexibility for future floor plan changes. In historic buildings, however, original ceilings in significant spaces should remain exposed to view. New suspended ceilings in standard office space within historic buildings should maintain the original ceiling height to the greatest extent possible, maintaining full clearance at windows and grouping systems, as necessary, to minimize the reduction of ceiling height. In office space containing vaulted ceilings, oversized windows, or similar features, consideration should be given to thoughtfully designed, exposed system solutions that maintain full ceiling clearance and allow ornamental surfaces to remain exposed to view.

The clear ceiling height for office spaces is a minimum of 2700 mm (9 feet) for spaces that are larger than 14 m^2 (150 square feet). The clear ceiling height of individual office rooms not exceeding an occupiable 14 m^2 (150 square feet) is a minimum of 2400 mm (8 feet). The clear ceiling height of private toilets and small closets, which are ancillary to other office spaces is a minimum of 2300 mm (7 feet 6 inches).

Enclosed offices should have the same ceiling height as adjacent open office spaces to allow future reconfiguration flexibility.

Automated Data Processing (ADP) Areas. ADP spaces require access flooring over a plenum space, even if access floors are not used elsewhere in the building. ADP areas are almost exclusively associated with main frame computer equipment. See Chapter 7, *Fire Protection Engineering*, for additional essential electronic facilities requirements.

The access flooring of ADP areas shall be level with adjacent related spaces and must always be level with the landings of elevators that serve the ADP facility. Ramps shall only be used where it is impossible to adjust the level of the structural floor. Where ADP areas occupy 33 percent or more of a floor, the entire floor, including internal corridors, shall be designed with raised access flooring to accommodate ADP facility expansion. The floor levels of access flooring should be constant throughout the floor.

Training and Major Conference Rooms. Individual training and conference rooms may be located within the building to best suit the tenant. If such spaces are grouped to form a large training or conference facility, they should be located near the ground floor to avoid excessive loading of vertical transportation and to provide immediate egress for large groups of people.

Rooms designed for video teleconferencing or training should have a minimum clear ceiling height of 3000 mm (10 feet).

Reagan Building, Washington, D.C.

Public Spaces

Public spaces are those accessible to the general public. They include entrances, lobbies, stairways, public elevator and escalator lobbies, and the permanent corridors at each floor level. In historic buildings, new materials should be commensurate in quality with original finishes and compatible in form, detail, and scale with original design.

Entrances and Vestibules. The main entrance to a Federal building must be conveniently located for vehicular and pedestrian traffic. All public entrances shall be accessible to physically challenged individuals.

A canopy, portico, or arcade should be used for weather protection, and to emphasize the main entrance or enhance the building design.

Approaches must be well-lighted and designed to direct the visitor to the entrance. Grade level approaches are preferred over elevated approaches that require steps, but need to be coordinated with overall approach to provide building security. Clear and attractive graphics should be provided to assist visitors with directions.

Entrance Lobbies and Atria. The lobby should be clearly visible from the outside, both day and night.

The main lobby should accommodate visitors by providing information facilities, waiting areas and access to vertical transportation. Since the lobby also serves as the collection point for all employees entering the building, it shall be designed to accommodate the high volume of pedestrian traffic. Areas such as cafeterias, auditoria and exhibition halls should be located near the lobby. Where appropriate, designers should strategize security design to make monumental interiors, atria, and other grand spaces suitable for after hours public use.

Even in non-secure buildings, lobby space shall be planned to be divisible into a non-secure and secure area, with space on the secure side to accommodate a future security station that may include an identity check, bag check, metal detector and turnstiles. Also allow for adequate queuing space on the future non-secure side of the lobby. Refer to Chapter 8 and the section on *Design Issues Affecting Security, Building Lobby* of this chapter for further details.

Access, maintenance and cleaning of the interior and exterior wall and ceiling surfaces (glazing and cladding) of multi-level lobbies or atria must be addressed during design, as well as maintenance and cleaning of light fixtures and servicing smoke detectors (if provided). Portable lifts or other appropriate equipment can be used to access these elements where approved by the Facility Manager; scaffolding should be avoided. The flooring materials within this space must be able to accommodate the loads and use of this equipment. Maintenance professionals should be included in Schematic and Design Development reviews to address these issues.

Mechanical, electrical and communication systems must be integrated into the lobby design. Fixture and outlet locations, and forms, sizes, finishes, colors and textures of exposed mechanical and electrical elements, must be coordinated with all other interior elements. It is desirable to conceal HVAC supplies and returns.

Elevator and Escalator Lobbies. Like entrance lobbies, elevator and escalator lobbies shall be designed to efficiently accommodate the movement of pedestrian traffic to other parts of the building. Adequate space should be provided to perform this function.

The elevator and escalator lobbies should be close to the main lobby and be visible from the main entrance. Visual supervision and physical control of the lobbies for elevators and escalators shall be a prime consideration for building security.

Public Lobby space.

If unusually large pieces of equipment or furniture such as mechanical equipment or conference tables must be transported to a specific floor via an elevator, verify that the item can be moved into and through the lobby space.

Public Corridors. A clear hierarchy should be visible in the treatment of spaces and corridors as they lead visitors from the entrance lobby to the main corridors and finally to departmental corridors. It is desirable to introduce as much natural light as possible into corridors, through windows, transoms or borrowed lights.

Building Support Spaces

Toilet Spaces. Toilet space includes general use toilets and associated vestibules, anterooms and contiguous lounge areas.

Toilet rooms for both sexes should also be located adjacent to the cafeteria.

Toilet rooms shall be screened from public view without the use of double door vestibules at entrances. All public and common use toilets must have facilities for the disabled and comply with UFAS and ADA *Accessibility Guidelines*. All other toilets must have provision for future adaptation to accessible requirements.

To the extent possible, toilets shall be grouped to reduce plumbing runs. The layout of toilets should minimize circulation space. However, toilet rooms for assembly areas, such as training or conference facilities, must accommodate short-term, high-volume traffic. In those areas, there shall be three women's toilets for every two toilets and/or urinals for men. Circulation should be adequate to handle peak traffic. In areas where assembly occupancies exist, provide fixtures consistent with code requirements for this occupancy.

- A fold-down changing table for infants should be available in toilets for public use.
- Feminine product dispensers shall be in each women's restroom.
- Toilet seat covers shall be provided in each restroom.
- Toilets for public usage shall be equipped with the large commercial toilet paper dispensers.
- Verify and get approval from the building management for the selection and placement of the following:
  – Commercial toilet paper dispensers
  – Soap dispensers.
  – Paper towel dispensers.
  – Paper towel trash receptacles.
  – Feminine hygiene products dispenser.
  – Feminine products disposal.
  – Toilet seat cover dispenser.

Toilet Partitions. All toilet partitions must be ceiling hung. They should be metal or similarly durable construction.

Toilet Accessories. Stainless steel is preferred for toilet accessories. Accessories should be integrated into the design of toilet rooms. Recessed and multi-function accessories that do not clutter the room are preferred.

Locker Rooms. Locker rooms shall be finished spaces. The shower area should be separated from the locker area. Regular gypsum wallboard is not to be used as a substrate for any shower room surface.

Custodial Spaces. Custodial spaces are devoted to the operation and maintenance of the building and include building maintenance storage rooms, stockrooms and janitor's closets. Custodial spaces shall be coordinated and approved by building management.

Storage Rooms. Storage rooms are utilitarian spaces. Rooms may be any configuration that will efficiently accommodate the materials to be stored. Access doors and aisles need to be large enough to move the stored materials. The configuration of storage rooms should be coordinated with the Facility Manager.

Janitor's Closets. Janitor's closets should be centrally located on each floor near the toilet facilities and be directly accessed from the corridor, not by going through the restrooms. They should accommodate all the equipment and supplies needed to service the area worked from the closet. All available space within the closet can be put to use to store gear and supplies. As a minimum, the service closet shall have a 600 mm (24-inch) square mop basin, a wall-mounted mop rack, and 900 mm (3 feet) of 250 mm (10-inch) wide wall shelving; the floor area should be a minimum of 1.7 m^2 (18 square feet).

Mechanical and Electrical Rooms. These spaces include, but are not limited to, mechanical and electrical equipment rooms, enclosed cooling towers, fuel rooms, elevator machine rooms and penthouses, wire closets, telephone frame rooms, transformer vaults, incinerator rooms, and shafts and stacks.

Equipment Spaces. Mechanical and electrical equipment rooms must be designed with adequate aisle space and clearances around equipment to accommodate maintenance and replacement. Hoists, rails and fasteners for chains should be provided to facilitate removal of heavy equipment. The working environment in equipment rooms should be reasonably comfortable. Doors and corridors to the building exterior must be of adequate size to permit replacement of equipment. This path (may include knock-out panels, hoists and provisions for cranes) is necessary and must be demonstrated for equipment replacement. Mechanical equipment rooms should not be less than 3700 mm (12 feet) clear in height. In some buildings special fire protection measures may be required. See Chapter 7: *Fire Protection Engineering,* for additional requirements.

All equipment spaces must be designed to control noise transmission to adjacent spaces. Floating isolation floors are recommended for all major mechanical rooms. See the section *Special Design Considerations, Acoustics, Design Criteria for Building Spaces, Class X Spaces* of this chapter for noise isolation criteria.

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

Mechanical rooms as a rule shall open from non-occupied spaces such as corridors. If mechanical rooms must open from occupied spaces because of configuration constraints consider incorporating a vestibule with partitions that extend to structure and sound-gasketed doors at each side for acoustic and vibration separation.

Communications Equipment Rooms. In addition to the criteria stated for general mechanical and electrical equipment rooms, equipment rooms for communications equipment must comply with EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins).

Equipment rooms shall be sized to accommodate the equipment planned for the room. At a minimum, the room should have 69 660 mm^2 (0.75 square feet) of equipment room space for every 9.3 m^2 (100 square feet) of occupiable space. The equipment room should be no smaller than 14 m^2 (150 square feet). Federal Technology Service (FTS) should determine if tenants will share equipment rooms or if separate equipment rooms are required for specific tenants.

Equipment rooms shall be connected to the communications entrance facilities and the backbone pathway.

The equipment room will have 24-hour HVAC service and be protected from contaminants.

Spaces for Uninterruptible Power Systems (UPS) and Batteries. The UPS modules and associated batteries must be installed in separate, adjacent rooms.

See the UPS and battery manufacturers' installation instructions for weights, dimensions, efficiency, and required clearances in the design. Allow space for storage of safety equipment, such as goggles and gloves. Special attention shall be given to floor loading for the battery room, entrance door dimensions for installation of the UPS and ceiling height for clearance of the appropriate HVAC systems and exhaust systems.

Electrical Closets. Electrical closets must be stacked vertically within the building. Closets shall be designed to contain adequate wall space and clearances for current and future requirements, and should have a minimum size of 1800 mm by 3000 mm (6 feet by 10 feet). Shallow closets must be at least 600 mm (24 inches) deep by 2600 mm (8 feet 6 inches) wide. These are satellite closets for electrical panelboards. They should not contain extraneous floor area, which may be an invitation to store items that do not belong in electrical closets.

Communications Closets. Communications closets must be stacked vertically within the building. Closets shall be sized to contain adequate floor space for frames, racks and working clearances for current need and future expansion. Communications closets shall meet the requirements of EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins). Agency requirements for separate, dedicated communication closets shall be verified.

Vertical Shafts. Vertical shafts for running pipes, ducts and flues shall be located adjacent to other core elements to the maximum extent possible. Be aware of the requirement to locate fire alarm vertical risers remotely. Shafts should be straight vertical runs. Shafts shall be sized to accommodate planned expansion of the systems. Shafts shall be closed at top and bottom, as well as at the entrance to the mechanical room, for sound isolation.

Loading Docks. Loading docks must be located for easy access by service vehicles and must be separate from the main public entrances to the building. Loading docks must be convenient to freight elevators so that service traffic is segregated from the main passenger elevator lobbies and public corridors. Service route from dock from elevator shall plan for the transport of large items such as rolled carpet goods. Loading docks must accommodate the vehicles used to deliver or pick up materials from the building. If the bed height of vans and trucks varies more than 450 mm (18 inches), at least one loading berth must be equipped with a dock leveler. The dock shall be protected with edge guards and dock bumpers. Open loading docks should be covered at least 1200 mm (4 feet) beyond the edge of the platform over the loading berth. In cold climates dock seals should be used at each loading bay. Alternatively, consideration could be given to enclosing the entire loading bay.

Separate or dedicated loading docks should be considered for food service areas.

A ramp should be provided from the loading dock down to the truck parking area to facilitate deliveries from small trucks and vans. This ramp should have a maximum slope of 1:12 and comply with UFAS/ADA Accessibility Guidelines, ensuring that it may be easily maneuverable for deliveries on carts and dollies.

If the building size warrants, a dock manager's room or booth should be located so the manager can keep the entire dock area in view and control the entrance and exit from the building.

Loading docks must not be used as emergency egress paths from the building.

Loading Berths. Provide at least one off-street berth for loading and unloading. The berth should be 4600 mm (15 feet) wide and at least as long as the longest vehicle to be accommodated. Local zoning regulations or the architectural program may require a longer length. The space should be located adjacent to the enclosed or open loading dock. If additional loading berths are required they need not be wider than 3600 mm (12 feet), as long as they are contiguous to the 4600 mm (15-foot) wide berth.

An apron space shall be provided in front of the loading berth for vehicle maneuvering equal to the length of the berth plus 600 mm (2 feet). This area should be flat, with a minimum slope of 1:50 for drainage. The minimum headroom in the loading berth and apron space is 4600 mm (15 feet). When a steeper slope is required in the apron area, the headroom should increase with a gradient allowance to allow trucks to traverse the grade change.

If the approach to the loading dock is ramped, the design should permit easy snow removal.

Staging Area. A staging area inside the building shall be provided adjacent to the loading dock. It must be protected from the weather. The staging area shall not interfere with emergency egress from the building.

Trash Rooms. Trash rooms shall be adjacent to loading docks or service entrances. Trash rooms must be sized to accommodate the trash handling equipment required and provide storage for packaged trash generated during a three day occupancy of the building. Space shall be allowed for sorting recycling of paper, glass and metals. Facilities that use trash containers that are picked up by vendors must have at least one loading berth for the trash container.

Building Engineer's Space. Even if not included in the building program, an office space for the building engineer should be evaluated. Most GSA buildings require such a space, which houses the consoles for the Building Automation System. This space is normally located near the loading dock or main mechanical spaces.

Security Control Center. All GSA buildings with a local security force should have a control center. In the event that the building will not be served by a local security force, this room could be combined with the building engineer's office or the fire control center.

The security control center should be located adjacent to the main lobby. Approximately 21 m^2 (225 square feet) should be allocated for this room which is intended to house the command station for the security guards and their equipment for current as well as future building needs. There should be an expectation in the planning of the building that a security command center and inspection station may be needed in the future, if it is not required at time of building design.

Fire Command Center. See Chapter 7: *Fire Protection Engineering*, for additional requirements.

Food Service Areas. The entrances to the dining area should be visible from the main circulation paths, but should not impede lobby traffic.

Space allocations for food service facilities are established in GSA handbook, *Concession Management Desk Guide (PMFC-93)*.

Dining Areas. Dining areas should be located to take advantage of natural light and outdoor eating areas in climates where this is feasible.

Serveries should be laid out to minimize waiting times for customers. Scramble service is recommended.

Child Care Centers. See GSA *Child Care Center Design Guide (PBS-P140)*. Child care centers will usually be operated by organizations outside the Federal Government. The GSA Office of Child Care Development Programs shall be consulted before design concepts are finalized.

Laboratories. The construction of new laboratories in existing office buildings is strongly discouraged. See Chapter 7: *Fire Protection Engineering,* for additional requirements.

Robert A. Young Federal Building Child Care Center, St. Louis, MO

Outleased Space. This term defines building space leased to businesses as commercial stores.

Outleased spaces and the connection between them and the remainder of the building should be designed so they can function as Government office space in the future. Consideration should also be given to those building without programmed outleased space to allow for this flexibility in the future.

Outdoor Eating Areas. To the extent possible, outdoor eating areas should be encouraged. When incorporating outdoor eating areas, the security of the building or facility shall be considered. Special consideration should be given to capture those opportunities to engage the building's exterior/landscaping with the community in which it is placed. See Chapter 2, *Site Planning and Landscape Design, Landscape Elements* and Chapter 8.

Structured Parking

The building program will stipulate the numbers and types of vehicle parking spaces. The program will also state whether parking is to be exterior on-grade parking or interior, structured parking. The following criteria apply to structured parking facilities and are minimum requirements. Dimensions apply to passenger cars and need to be modified for other types of vehicles.

Parking Layout. To the extent possible, parking spaces should be arranged around the perimeter of the parking deck for maximum efficiency. Two-way drive aisles should be used with 90-degree vehicle parking stalls on each side. When locating entrances and ramps, consider internal and external traffic flow, queuing during peak periods of ingress and egress, and required security features.

Drive Aisles. Two-way aisles must have a minimum width of 7000 mm (23 feet). One-way aisles and aisles with stalls on only one side are less efficient and should be avoided if possible.

Vehicle Stalls. Stalls to accommodate regular passenger cars should have be sized to comply with local zoning requirements. When there are no zoning requirements then parking spaces should be a minimum size of 2600 mm (8 feet 6 inches) wide and 5500 mm (18 feet) long. No special consideration should be given to compact vehicles. No structural element may intrude upon the required stall dimension, and columns must not be located within 610 mm (2 feet) of the required aisle except where the aisle has no stalls perpendicular to it. Each stall must have access to an aisle.

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Accessible parking spaces must be provided; these must comply with UFAS/ADA *Accessibility Guidelines* for quantity, location and size. Accessible parking spaces shall be adjacent to access aisles that are part of an accessible route to the building or facility entrance. Accessible routes shall not be located behind parking spaces.

Ramps. The incline on parking area ramps shall not exceed 12 percent. The break-over angle at changes of plane in ramps shall not exceed 6 percent. The incline on ramp floor garages shall not exceed 5 percent. The entire length of the entrance and exit ramps must be protected so that snow and ice do not accumulate on the ramps if inclement weather is excessive. Snow melting systems should also be considered. Careful consideration needs to be given to providing proper drainage of the parking deck.

Garage Openings. Overhead doors or grilles at vehicular entries to structured parking garages may be provided for security purposes. The operation of overhead doors or grilles must utilizes advanced technology (use of sensors or incorporating sallyports) to prevent entry by unauthorized persons. These overhead grilles or doors shall be electric and operated by card-readers or other means of remote control. The control devices and doors or grilles shall be suited for high frequency operation, and should open and close quickly to avoid impact damage to vehicles; they must also have a sensor edge to detect a vehicle or other object below it and reverse operation. These openings should be monitored by camera.

These openings shall be a minimum of 3600 mm (12 feet) wide with minimum height of 2400 mm (8 feet). A headache bar shall be provided in front of each opening; this shall be mounted 100 mm (4 inches) lower than the height of the clear opening.

Walkways. Pedestrian walkways shall link the parking area with the building entrance. Provide curbs, bollards, other barriers or low walls to prevent vehicles from encroaching upon pedestrian walkways. Identify pedestrian crossings of vehicular traffic lanes by painted crosswalks and signage.

3.3 Commissioning

The design architect shall identify and coordinate commissioning practices with the Construction Manager, Project Manager, and (if contracted separately) the Commissioning Authority, for the project's programmed performance goals. As appropriate, coordinate with other disciplines to fully enable required testing and certifications. Incorporate into construction specifications those testing and certification requirements that involve construction contractors. Examples of possible programmed performance goals include:

- Assigned Annual Energy Consumption Goal
- Attainment of Programmed LEED rating
- Assured Envelope Thermal Integrity, Certified by Hot-Box and/or Infra-red (thermographic) Imaging
- Water Penetration and/or Moisture Control
- Blast Resistance Glazing Performance
- Seismic Response
- Acoustic Performance
- High-wind Impact Resistance
- Accessibility Requirements
- Functionality of Applied Innovative Technologies

3.4 Special Design Considerations

Incorporation of Recycled-Content Materials

The GSA is committed to maximizing the use of recycled-content materials specified in the construction of Federal building projects. Many commonly used products are now available with recycled content, including steel, aluminum, concrete, masonry, acoustic tile, paint, carpet, ceramic tile, and insulation.

To support markets for the materials collected in recycling programs, the Resource Conservation and Recovery Act requires agencies to buy recycled-content products designated by EPA. Through the Comprehensive Procurement Guidelines (CPG), EPA designates items that must contain recycled materials when purchased by Federal agencies, or government contractors, using appropriated Federal funds. Refer to Chapter 1, *Recycled-Content Products.*

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

The CPG items listed in table 3-3 are frequently found in buildings. Product specifications and standards that might exclude the use of recovered materials should be revised to allow the use of these items.

Table 3-3
Examples from the CPG List of Designated Products

Building Insulation Thermal insulation made from recovered materials is available in several forms including rolls, loose-fill, and spray foam. Insulation can include a range of recovered materials such as glass, slag, paper fiber, and plastics.

Carpet Recycled-content polyester carpet is available for light- and moderate-wear applications. Recycled fiber polyester carpet is manufactured from PET recovered soda bottles.

Carpet Cushion Carpet cushion, also known as carpet underlay, is padding placed beneath carpet. Carpet cushions made from bonded urethane, jute, synthetic fiber, and rubber can be made from recovered materials.

Cement and Concrete Coal fly ash and ground granulated blast furnace (GGBF) slag are recovered materials that can be used as ingredients in cement or concrete. Coal fly ash is a byproduct of coal burning at electric utility plants. Slag is a byproduct of iron blast furnaces. The slag is ground into granules finer than Portland cement and can be used as an ingredient in concrete. The level of coal fly ash in concrete typically ranges from 15 to 35 percent of total cementitious material, but can reach 70 percent for use in massive walls and girders. The level of GGBF slag usually ranges from 25 to 50 percent.

Reprocessed and Consolidated Latex Paints For Specified Uses Reprocessed paint is postconsumer latex paint that has been sorted by a variety of characteristics including type (i.e., interior or exterior), light and dark colors, and finish (e.g., high-gloss versus flat). Reprocessed paint is available in various colors and is suitable for both interior and exterior applications. Consolidated paint consists of postconsumer latex paint with similar characteristics (e.g., type, color family, and finish) that is consolidated at the point of collection. Consolidated paint is typically used for exterior applications or as an undercoat.

Structural Fiberboard and Laminated Paperboard Structural fiberboard is a panel made from wood, cane, or paper fibers matted together which is used for sheathing, structural, and insulating purposes. Laminated paperboard is made from one or more plies of kraft paper bonded together and is used for decorative, structural, or insulating purposes. Examples of these products include building board, insulating formboard, sheathing, and acoustical and non-acoustical ceiling tile.

Floor Tiles and Patio Blocks Floor tiles for heavy duty or commercial specialty applications can contain up to 100 percent postconsumer rubber. Floor tiles containing 90 to 100 percent recovered plastic are also readily available. Patio blocks made from 90 to 100 percent recovered plastic and 90 to 100 percent postconsumer rubber are used for walkways and trails.

Shower and Restroom Dividers / Partitions Shower and restroom dividers/partitions are made of 20 to 100 percent recovered plastic or steel. They are used to separate individual shower, toilet, and urinal compartments in commercial and institutional facilities.

Signage Signs made from recovered materials are used inside and outside of office buildings and other public places. EPA's designation pertains to plastic signs used for nonroad applications and covers any associated plastic or steel supports.

Concrete

Because concrete is one of the most widely used building products, incorporation of recycled materials that do not impact strength may make a substantial contribution to the nation's recycling effort.

The following is a list of specifications for cement and concrete containing recovered materials:

Cement Specifications:

- ASTM C 595: Standard Specification for Blended Hydraulic Cements.
- ASTM C 150: Standard Specifications for Portland Cement.

Concrete Specifications:

- ASTM C 618, "Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete."
- ASTM C 311, "Standard Methods of Sampling and Testing Fly Ash and Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete."
- ASTM C 989, "Ground Granulated Blast-Furnace Slag for Use in Concrete Mortars."
- American Concrete Institute Standard Practice ACI 226.R1. "Ground Granulated Blast-Furnace Slag as a Cementitious Constituent in Concrete."

Acoustics

The standards in this section have been established to ensure adequate acoustic qualities in Federal buildings.

Design Criteria for Building Spaces. Every element of a built space, including its shape, surfaces, furniture, light fixtures and mechanical systems contribute to its acoustical characteristics. Four key concepts govern the perceived quality of office acoustics:

- **Appropriate levels of speech privacy.** Speech privacy refers to the degree to which a conversation cannot be overheard in an adjacent space. Lawyers, doctors, human resources officers, executives and others whose position requires them to discuss sensitive information require confidential speech privacy, that is, a setting where, when a door is closed, the content of a conversation cannot be overheard. Professional staff members whose position requires extended periods of concentration require normal speech privacy, where the content of conversation in adjacent spaces cannot be overheard without making an effort, providing freedom from distraction. Little or no speech privacy is needed for receptionists, clerical staff, and team-oriented workgroups where overheard conversation can actually be beneficial.

- **Appropriate levels of background sound.** Continuous background sound in offices is mostly generated by heating, ventilation, and air conditioning (HVAC) equipment. In conference spaces, courtrooms and auditoria, it is important that this background sound not interfere with the intelligibility of speech. In enclosed offices, HVAC background sound is an important component in achieving the required level of privacy because it helps to cover up or "mask" speech transmitted between adjacent spaces. In open plan areas, the background sound provided by contemporary HVAC equipment is often not uniform and/or does not have the tonal balance and loudness needed to mask speech transmitted between adjacent cubicles. For this reason, additional electronic background noise or sound masking is often deployed in these areas.

- **Control of intrusive noise, vibration, and reverberation.** Office equipment generating noise levels above the background should be located away from primary work areas or should be surrounded by acoustically isolating panels. Noise induced by mechanical equipment should be controlled through vibration isolation devices, appropriate placement of equipment and noise attenuators in ducts. Reverberation and echoes must be controlled in courtrooms, auditoria, conference, team, and training room spaces. Sound absorbing materials are used to help control reflected sound energy and echoes. Particular attention must be paid to rooms with parallel walls (causes "flutter" echoes) and rooms with curved or concave ceilings (leads to acoustical focusing effects).

- **Isolation from exterior noise sources.** Buildings located near airports, highways, rail corridors or other sources of significant environmental noise levels must have exterior wall and window assemblies controlling noise intrusions.

Parameters Used in Acoustical Design. The following parameters are used to specify acoustical standards for GSA buildings:

Background Noise. The continuous noise within a space. The loudness of noise is quantified by several assessment schemes, including *noise criteria* (NC), *balanced noise criteria* (NC-B) and *room criteria* (RC) contours. These contours are published in the ASHRAE *Handbook of Fundamentals.* Lower values are quieter.

Noise Isolation. The amount of noise transmitted through the perimeter boundary elements of a space. *Sound transmission class* (STC) describes the sound insulating performance of building elements such as walls, windows, and doors when tested in accordance with ASTM E90. *Ceiling attenuation class* (CAC) quantifies the sound insulating performance of a ceiling assembly spanning across rooms that share a common plenum when tested in accordance with ASTM E1414. *Impact insulation class* (IIC) describes the impact sound insulating properties of a floor/ceiling assembly when tested in accordance with ASTM E492. Greater STC, CAC or IIC values represent better performance.

Sound Absorption. The amount of sound absorbed by a surface finish. *Sound absorption average* (SAA) quantifies the efficiency of a material in absorbing sound energy when tested in accordance with ASTM C423 (SAA replaces the earlier *noise reduction coefficient* or NRC). SAA/NRC is a single number rating between 0 and 1. Greater SAA/NRC values represent a more effective sound absorber. An excessive amount of reflected sound (reverberation) tends to degrade speech communication.

Speech Privacy. This parameter refers to the lack of intelligibility in a space adjacent to the location where a conversation is occurring. Articulation index (AI) quantifies the degree of speech clarity when tested in accordance with ASTM E1130. AI is a single number rating between 0 and 1; lower AI values mean fewer words can be understood, indicating increased privacy.

Design Criteria for Building Spaces. Acceptable acoustics are determined by the use of a space and the requirements of its occupants. It is the responsibility of the design team to meet the following minimum standards governing the acoustical performance of various space usage categories.

Class A1. This category describes critical, noise-sensitive spaces that must provide optimum speech intelligibility—including auditoria, teleconference facilities and courtrooms. The acoustical treatment of these spaces shall be designed by a qualified acoustical consultant or specialist approved by the GSA project manager. The acoustical design should based on an analysis of the user's needs and a design brief shall be prepared for review by the GSA project manager. Pre-occupancy testing shall verify that the acoustical performance has been achieved. Note: U.S. court facilities must be designed in accordance with Chapter 9 of this document: *Design Standards for U.S. Courts Facilities.*

Class A2. Enclosed spaces where meetings take place, including conference and training rooms. HVAC-background noise shall not exceed NC/RC 30. Supply and return air systems shall be designed to control speech sounds transmitted between spaces. Partitions enclosing Class A2 space shall have a minimum STC of 50 and extend from the floor to the deck above the finished ceiling. Doors to corridors shall be gasketed. Doors or operable partitions dividing spaces into smaller sub-spaces shall have a minimum STC of 50. A minimum of 25% of wall surfaces and 50% of ceiling surfaces shall incorporate sound-absorptive materials with a minimum SAA/NRC of 0.75.

Class B1. Enclosed spaces requiring confidential speech privacy, including judicial chambers, medical examination rooms and certain private offices. The acoustical treatment of these spaces shall be designed by a qualified acoustical consultant or specialist approved by the GSA project manager in order to provide a 'confidential' level of speech privacy. The design criteria for Class A2 spaces may be substituted in lieu of design assistance by an acoustical consultant.

Class B2. Private offices requiring normal speech privacy. The acoustical treatment of these spaces shall be designed with the assistance of a qualified acoustical consultant or specialist in order to provide a 'normal' level of speech privacy. The following design may be substituted in lieu of design assistance by an acoustical consultant:

(1) HVAC-related sound shall not exceed NC/RC 35;
(2) Supply and return air systems shall be designed to control speech sounds transmitted between spaces;
(3) Partitions enclosing Class B2 spaces shall have a minimum STC of 45 and all corner/ceiling/floor connections shall be sealed with acoustical caulk;
(4) Acoustical ceiling shall have a minimum SAA/NRC of 0.65 and a minimum CAC of 35;
(5) HVAC-background noise or electronic sound masking shall generate a continuous minimum noise level of NC/RC 30.

Class B3. Open plan and shared offices requiring normal speech privacy. The acoustical treatment of these spaces shall be designed with the assistance of a qualified acoustical consultant or specialist in order to provide a 'normal' level of speech privacy. Pre-occupancy testing shall verify that a maximum AI of 0.20 has been achieved.

Class B4. Open plan and shared offices where speech privacy is not required. HVAC background noise shall not exceed NC/RC 40. A minimum of 25% of wall surfaces and 80% of ceiling surfaces shall incorporate sound-absorptive materials with a minimum SAA/NRC of 0.75. Wherever possible, carpeted floors shall be used.

Class C. Areas where people assemble and converse, including dining rooms, lunchrooms, lobbies and atria. When located adjacent to Class A or Class B space, partitions enclosing Class C space shall extend from the floor to the deck above the finished ceiling and have a minimum STC of 50. A minimum of 25% of wall surfaces and 80% of ceiling surfaces shall incorporate sound-absorptive materials with a minimum SAA/NRC of 0.65.

Class D1. Occupied space where speech privacy is not a significant consideration, including internal corridors, mailrooms and file rooms. For corridors adjacent to open plan areas, a minimum of 80% of ceiling surfaces shall be treated with sound-absorptive materials having a minimum SAA/NRC of 0.65. Wherever possible, these same corridors shall be carpeted.

Class D2. Support spaces including fire stairs, toilets and locker rooms. Where possible, Class D2 spaces should not be placed adjacent to Class A and Class B spaces. When Class D2 spaces must be located adjacent to Class A or Class B space, partitions enclosing Class D2 space shall have a minimum STC of 50 and extend from the floor to the deck above the finished ceiling.

Class E. Spaces where concentrations of noisy equipment are located, including Automated Data Processing areas, computer equipment facilities, and rooms containing high-speed copiers. Where possible, Class E spaces should not be placed adjacent to Class A and B spaces. When Class E spaces must be located adjacent to Class A or B space, partitions enclosing Class E space shall have a minimum STC of 50 and extend from the floor to the deck above the finished ceiling. A minimum of 25% of wall surfaces and 100% of ceiling surfaces shall be treated with sound-absorptive materials with having a minimum SAA/NRC of 0.55.

Class X. Warehouses, parking garages, kitchens and spaces where noisy operations are performed. Other examples include elevator machine rooms, trash compactor rooms, mechanical and electrical /telecommunications equipment rooms. Where possible, Class X spaces should not be placed adjacent to Class A and B spaces. When Class X spaces must be located adjacent to Class A or B space, partitions and floor/ceilings bounding Class X space shall have a minimum STC/IIC of 60. The bounding partitions shall extend from the floor to the deck above the finished ceiling. Mechanical equipment in Class X spaces shall control vibration transmitted into the building systems. When Class X spaces are continuously or intermittently occupied, wall and/or ceiling surfaces shall be treated with sound absorptive materials to help reduce the risk of hearing damage as prescribed by the Occupational Safety and Health Administration (OSHA).

Acoustical criteria for specific types of spaces are described in Table 3-4. A description of these types of spaces follows.

Emergency Protection

Federal law requires that Federal buildings provide protection suitable for emergency shelters within program and budgetary limits. The program will state if shelters are required on a given project. Emergency shelters are not designated building spaces: they are spaces used for other purposes, which can serve as shelters in an emergency.

Shelter locations should be identified during the early stage of design. The optimum shelter location is below grade. Basement levels, including underground parking facilities, offer good protection.

Table 3-4
Acoustical Criteria by Type of Space

Class of Space/Typical Uses	Maximum NC	Maximum L_{eq}	L_{max}	Maximum Mid-frequency RT_{60}
Class A1[2] **Auditoria, teleconference facilities, courtrooms**	20	30	40	1.0
Class A2 **Meeting rooms**	25	35	45	1.0
Class B1 **Private offices, confidential speech privacy**	30	40	50	N/A
Class B2 **Private offices, normal speech privacy**	30	40	50	N/A
Class B3 **Open plan offices**	40	50	60	N/A
Class C **Lunchrooms and lobbies**	40	50	60	N/A[5]
Class D1 **Corridors, mail and file rooms**	45	55	65	N/A
Class D2 **Toilets, locker rooms, stairs**	45	N/A	N/A	N/A
Class E **Office equipment rooms**	45	N/A	N/A	N/A
Class F **Warehouses and parking**	N/A	N/A	N/A	N/A
Class X **Kitchens and bldg. equipment**	N/A	N/A	N/A	N/A

Minimum NRC of absorptive ceiling materials/minimum % of ceiling surface	Minimum NRC of absorptive wall materials/minimum % of wall surface[1]	Minimum STC Performance Between Adjacent Spaces	
		Class A, B space Adjacent	Class C, D, E, F, or X Adjacent
0.8/ 50%	0.8/ 25%	55	55
0.8/ 50%[3]	0.8/ 25%	50	50
N/A	0.8/ 25%	50	50
N/A	0.8/ 25%	38[4]	38[4]
0.8/ 100%	0.8/ 25%	28	38[4]
0.65/ 50%	0.8/ 25%	N/A	38[4]
0.65/ 100%[6]	0.8/ 25%	N/A	38[4]
N/A	N/A	N/A	N/A
0.65/ 100%	0.8/ 25%	N/A	N/A
N/A	N/A	N/A	N/A
N/A[7]	N/A[7]	N/A	N/A

1 These percentages may be reduced or eliminated if the walls are not parallel and/or there are bookcases, louvered doors, or other materials that will diffuse sound. Absorptive materials must be located a minimum of 4 feet above finished floor level. In Class A and B1 spaces, absorptive materials should be located on two adjacent walls, one of which should be the rear wall.

2 These are baseline standards. Criteria for Class A1 spaces must be established by an acoustical consultant or specialist based on an analysis of the user's needs. Technical documentation of these criteria shall be submitted as part of design documentation, and used to verify performance prior to occupancy of space.

3 65 NRC may be used if it absorptive material covers 100% of ceiling.

4 Satisfied by standard wall: 3 5/8" metal stud, 2" batt insulation, 1 layer 5/8" gypsum board each side, all perimeter connections (corner/ceiling/floor) sealed with acoustical sealant. Walls that terminate at underside of suspended ceiling: ceiling must have a minimum CAC of 35 with 2" batt insulation above or be constructed of gypsum board. Open return air plenum not permitted without acoustical boot.

5 In lobbies where speech will occur, 1.0.

6 Absorptive ceiling materials for Class D1 spaces are required only for corridors adjacent to open plan areas, but are recommended where practical for all corridors and file rooms.

7 Sound absorbing materials as required in occupied spaces to protect employees from hearing damage as prescribed by OSHA.

U.S. Courthouse at Foley Square, New York, NY

3.5 Building Elements

This section establishes design guidelines for the various building elements, which are defined as the physical parts of building construction. These may be individual materials, assemblies of materials, equipment, or assemblies of materials and equipment.

It is the architect's responsibility to specify construction materials and systems appropriate to the final design. For special requirements on fire protection see Chapter 7: *Fire Protection Engineering*.

Substructure

Ground Water Control. The drainage mat and soil filter should relieve hydrostatic pressure on substructure walls and allow water drainage to the level of the drain. Drainage system piping may be clay tile or rigid PVC. Pipes should not slope less than 1:200. Subsurface drainage should discharge into the storm drain, by gravity if possible. Cleanouts shall be provided at grade to facilitate washing out the system.

Waterproofing. Membrane waterproofing should follow the recommendations of the National Roofing Contractors Association (NRCA) as contained in *The NRCA Waterproofing Manual*.

Underslab Insulation. Provide insulation under concrete slabs on grade where a perma-frost condition exists, where slabs are heated, and where they support refrigerated structures.

Exterior Closure

Products constructed of carbon steel are not permitted in exterior construction, which includes exterior walls, soffits or roofs, except where protected by a galvanic zinc coating of at least 460 grams per m^2 (1.5 ounces per square foot) of surface or other equivalent protection.

Exterior Wall Construction. Brick masonry design shall follow the recommendations of the Brick Institute of America (BIA) contained in the publications, *Technical Notes on Brick Construction*.

Concrete masonry design shall follow the recommendations of the National Concrete Masonry Association (NCMA) contained in the publication, *TEK Notes*.

Architectural precast concrete design shall follow the recommendations of the Precast Concrete Institute (PCI) contained in PCI publication, *Architectural Precast Concrete*, Second Edition.

Exterior limestone veneer design shall follow the guidelines of the *Handbook on Indiana Limestone* published by the Indiana Limestone Institute of America.

Marble veneer design shall follow the recommendations in *Exterior Marble Used in Curtain or Panel Walls* published by the Marble Institute of America.

Vapor retarder must be provided in a building envelope where heat loss calculations identify a dewpoint within the wall construction and in any building or part of any building that is mechanically humidified.

Exterior Cladding and Articulation. The use of different exterior materials, window designs, sun control devices and other design elements contribute to the design articulation of a building. Each of these components, their use and how they are combined on a building must be reviewed for opportunities provided for birds to roost ("bird roosts") on the exterior of the building. "Bird roosts" can create both maintenance and visual problems, particularly in high-rise buildings.

Such opportunities for 'bird roosts' must be identified in the design phase and alternatives ways to address this be pursued. Consider the use of steeply sloped surfaces, limited use of horizontal surfaces at window sills, sun control devices or other design features or design approaches to address this issue. See the *Sun Control Devices* section of this chapter.

Sun Control Devices. Projecting exterior sun screens may be used in addition to interior sun control devices where they are beneficial for building operation and energy conservation. Exterior shutters, blinds and awnings should not be used.

Design elements such as steeply angled fins or large scale gratings, instead of horizontal fins and flat planes, should be considered for sun screen components to provide shading for a building.

Consideration shall be given to operable and fixed sun control devices for maintenance, repair and replacement. Window washing systems used for the facility must also be compatible with any sun screens or sun control devices.

Glazing, shading devices, and sources of illumination should be analyzed in detail to minimize heat gain and maximize direct natural light into all spaces to produce the best microclimate for tenants in building perimeter spaces.

Exterior Soffits. Design exterior soffits to resist displacement and rupture by wind uplift. Design soffits for access to void space where operating equipment is located or maintenance must be performed. Soffits can be considered totally exposed to weather and should therefore be designed to be moisture resistant. Provide expansion and contraction control joints at the edges and within the soffit. Spacing and configuration of control

Sam Gibbons U.S. Courthouse, Tampa, FL

joints should be in accordance with the recommendations of the manufacturer of the soffit material.

Operating equipment or distribution systems that may be affected by weather should not be located inside soffits. Where it is necessary to insulate the floors over soffits, the insulation should be attached to the underside of the floor construction so that the soffit void may be ventilated to prevent condensation.

Exterior Windows. Although fixed windows are customary in large, environmentally controlled GSA buildings, in certain circumstances operable windows may be appropriate. Sometimes operable windows can also be used as a means of smoke control. In addition, operable windows may be used where they provide for window washing operations. In such cases, the operable windows should be able to be washed from the interior side. Replacement of windows in historic structures should exactly match original frame and munton profiles. First consideration should be given to rehabilitating the existing windows.

Consideration of glare control plus heating and cooling loads must be factored into decisions on amount and placement of windows.

Aluminum windows shall meet the requirements of ANSI/AAMA Standard 101-85. Only Optional Performance Classes may be used. Metal windows other than aluminum shall meet the requirements of the National Association of Architectural Metal Manufacturers Standard SW-1 for the performance class required. Wood windows should meet the requirements of ANSI/NWMA Standard I.S. 2-87, Grade 60.

Aluminum frames must have thermal barriers where there are more than 1670 heating degree days °C (3,000 heating degree days °F). Window mullions, as much as possible, should be located on the floor planning grid to permit the abutment of interior partitions.

Glazing. The choice of single, double or triple glazed windows should be based on climate and energy conservation and security requirements. Use thermally broken frames when double and triple glazing units are specified. Highly reflective glass that produces mirror images should be used with care to avoid creating glare in surrounding streets and buildings.

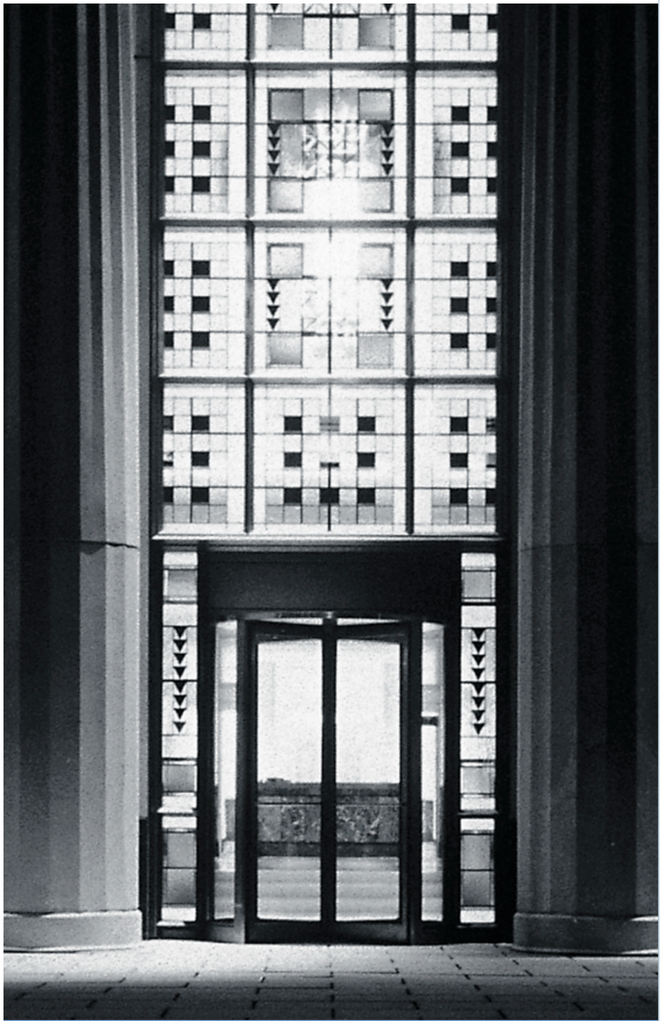
Condensation Resistance. Windows should have a condensation resistance factor (CRF) adequate to prevent condensation from forming on the interior surfaces of the windows. The CRF can be determined by testing in accordance with AAMA 1502.7, *Voluntary Test Method for Condensation Resistance of Windows, Doors and Glazed Wall Sections*. Where a CRF in excess of 60 is required, do not use windows unless some condensation can be tolerated or other methods are used to prevent or remove condensation.

Window cleaning. The design of the building must include provisions for cleaning the interior and exterior surfaces of all windows. Window washing systems used in the region must be considered and a preferred system and equipment identified during design. In large and/or high-rise buildings, such glass surfaces as atrium walls and skylight, sloped glazing, pavilion structures, and windows at intermediate design surfaces must be addressed. See also the *Building Specialties, Window Washing Equipment* section of this chapter.

Exterior Doors. Entrance doors may be aluminum and/or glass of heavy duty construction. Glazed exterior doors and frames shall be steel and meet the requirements of SDI Grade III with a G-90 galvanic zinc coating. Vestibules are desired to control air infiltration. Sliding automatic doors are preferred over swinging type. Motion detectors and push plates are preferred over mats as actuating devices.

Overhead coiling doors are preferred for loading docks. At least one personnel door should be provided in addition to the overhead doors.

Hardware for Exterior Doors. Hinges, hingepins and hasps must be secured against unauthorized removal by using spot welds or peened mounting bolts. All exterior doors must have automatic closers. The exterior side of the door shall have a lock guard or astragal to prevent jimmying of the latch hardware. Doors used for egress only should not have any operable exterior hardware. See Chapters 7 and 8 for additional information.



Robert C. Byrd Courthouse, Charleston, WV

Oakland Federal Building, Oakland, CA

Roofing. Roofing design shall follow the recommendations of the National Roofing Contractors Association as contained in NRCA publication, *NRCA Roofing and Waterproofing Manual*. The design of metal flashing, trim, and roofing shall follow the recommendations of the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) publication, *Architectural Sheet Metal Manual*.

Roof Drainage. Dead level roofs are not permitted. Roof drains or scuppers are the only low points permitted. Provide a minimum slope to drains of 1:50 on roofing surfaces. When providing roof slope, consider sloping the structural roof deck. Over the life of the building this may be less expensive than providing tappered insulation each time the roof is replaced. Roofs shall not be used to retain water.

Insulation. Roof insulation should be installed in a minimum of two layers to minimize thermal breaks in the roof system.

Access to Roof. An interior permanent stair should be provided to permit access to roof-mounted equipment. Permanent access to all roof levels should be provided to facilitate reoccurring inspection and maintenance.

Roof-Mounted Equipment. Roof-mounted equipment shall be kept to a minimum and must be housed in penthouses or screened by walls. Penthouses and screen walls should be integrated into the building design and constructed of materials used elsewhere in the building exterior. Some roof-mounted equipment, such as antennae, lightning rods, flagpoles, etc., do not have to be screened, but these elements must be integrated into the building design. Roof-mounted equipment should be elevated as recommended in the NRCA Roofing and Waterproofing Manual and set back from the roof edge to minimize visibility. Critical roof-mounted equipment should be installed in such a way to permit roof system replacement or maintenance without disruption of equipment performance.

Penetrations through the roof to support equipment are extremely vulnerable to leaks. Flashing details must be studied for appropriate continuation of the waterproof barrier. Pitch pocket details should not be used,

No building element may be supported by the roofing system except walkways. Provide walkways on the roof along routes to and around equipment for maintenance.

Skylights and Sloped Glazing. Skylights are defined as pre-fabricated assemblies shipped ready for installation, while sloped glazing is defined as field-assembled. Skylights design shall follow the guidelines of the AAMA Standard 1600. For the design of sloped glazing, two AAMA publications are available: *Glass Design for Sloped Glazing* and *Structural Design Guidelines for Aluminum Framed Skylights*.

Skylights and sloped glazing should use low emissivity glass. Placement should be calculated to prevent glare or overheating in the building interior. Condensation gutters and a path for the condensation away from the framing should be designed.

Consideration shall be given to cleaning of all sloped glazing and skylights, including access and equipment required for both exterior and interior faces. See also *Building Elements, Cladding and Articulation* and *The Buildings Specialties, Window Washing Equipment* sections of this chapter.

Thermographic Testing. In order to verify performance related to the design intent of the exterior building envelope, regarding thermal resistivity, thermographic testing shall be performed at various conditions on the finished construction and before occupancy. This testing will verify that the actual construction meets the requirements as specified.

Cornerstone

A cornerstone is required for all new buildings as a part of the exterior wall. The cornerstone should be a cut stone block having a smooth face of size adequate to present the following incised letters: UNITED STATES OF AMERICA, (PRESIDENT'S NAME), PRESIDENT, GENERAL SERVICES ADMINISTRATION, (ADMINISTRATOR'S NAME), ADMINISTRATOR, (YEAR OF PROJECT COMPLETION). The words, UNITED STATES OF AMERICA, should be in letters 50 mm (2 inches) high and other letters should be proportionally sized by rank.

All names should be of those individuals in office during project development prior to construction, if construction is completed during a subsequent President's term of office.

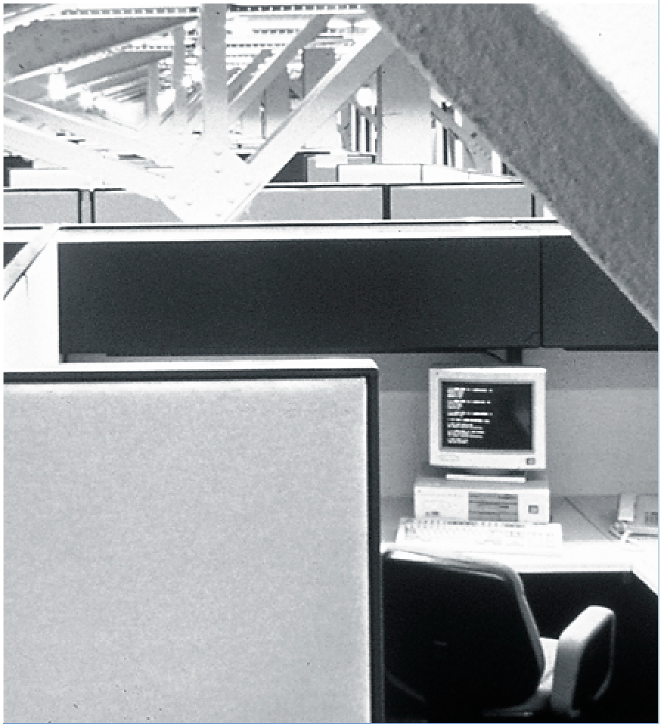
Interior Construction

Partitions. Partitions should be selected for use based on the type of space and the anticipated activity within that space. The following should be evaluated: the volume of people; their activities; the type, size, weight and function of equipment (mail carts, forklifts, etc.) that will be used in the space; and any free-standing, moveable or wall-mounted equipment that will impose lateral loads (built-ins, wall-mounted televisions, etc.).

Each potential wall system must be evaluated for structure, backing, finish and protection factors. GSA prefers partition systems that are simple to construct, made from readily available materials, economical and easily moved and reassembled by common laborers.

Metal stud systems must meet the requirements ASTM C754. The application and finishing of gypsum board should follow standard ASTM C840. Adequate tolerances should be designed where the top of a partition abuts the underside of the building structure; allow for deflection and long term creep.

Partitions used at the perimeter of a humidified space must include a vapor barrier. In computer rooms the need for air plenum dividers below the floors must be checked.



Postal Square, AOC Workstation

Interior Finishes. Refer to the section on *Interior Finishes* in this chapter.

Interior Doors. Interior doors in tenant spaces should be flush, solid-core wood doors. Steel door frames should meet the requirements of SDI *Recommended Erection Instructions for Steel Frames*. Provide matching-edge veneers for transparent-finished wood doors. Avoid the use of wood door frames except to match wood doors in specially designed areas.

Ceiling Suspension Systems. The design of suspension systems for acoustical ceilings must meet the requirements of ASTM C.635 for heavy-duty systems and ASTM C.636. When designing a suspended ceiling system with drop-in components, such as lighting fixtures, specifications may not be incorporated that can only be satisfied by hard metric versions of recessed lighting fixtures unless market research of cost and availability has been done as outlined in Chapter One; *General Requirements, Metric Standards, Metric Policy Guidelines*.

Access Flooring

Accessible floor systems are a high priority for incorporation in all GSA buildings, where it is practical. They have the potential of requiring the least impact on floor to floor heights for accommodating building systems. The flexibility allowed by accessible flooring recognizes the dynamic changes that occur in the use of the space and the continual upgrades that occur to building environmental and communication systems. Refer also to the *Technology Infrastructure* section of Chapter 3.

If no load requirements are stated in the building program, design access flooring for 1210 kg/m^2 (250 PSF) uniform load and 910 kg (2,000 pound) point load. Generally, floor panels should be concrete filled metal or concrete. Both pedestal and stringer systems are acceptable; however, for heavy cart traffic, stringer systems are preferred. The system must be coordinated with the design of the underfloor junction box for electrical power and communications. Designs should be selected recognizing the potential for frequent removal and replacement of raised access floor tiles. Systems that require extensive bolting and unbolting are not desirable.

For tiles with hard-surface finishes, access floor tiles shall have a high pressure plastic laminate surface; this will reduce static and dust associated with these areas. In order to reduce static in computer areas, consider the use of conductive laminated plastic, bonded to the access panels with a conductive adhesive. The building flooring under the access flooring, typically concrete, should be sealed to prevent the accumulation of concrete dust in this area. Access floor tiles may be finished with carpet tile. Bolted connections between pedestal and floor are preferred in seismic zones.

Building Specialties

Window Washing Equipment. Generally, window washing and exterior maintenance are performed by maintenance contracting firms that provide their own powered platforms, scaffolding, or chair lifts to perform these functions. To accommodate the use of maintenance equipment, suitable engineered systems shall be designed and incorporated into the building design. The design will be for buildings three stories or 12,200 mm (40 feet) and higher, and shall conform to OSHA Standard 29 CFR 1910.66, Subpart F - *Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms*, ANSI Standard A120.1, *Safety Requirements for Powered Platforms for Building Maintenance*, and ANSI Standard A39.1, *Safety Requirements for Window Cleaning*.

Waste Removal Equipment. Waste is normally removed from GSA buildings by contract maintenance firms. The firm will usually collect the waste from receptacles in the occupied spaces into carts, which will be taken to larger containers at the waste pick-up station. The firm will usually provide the containers as part of its contract.

The minimum architectural requirements for waste removal are: access for waste handling equipment from the occupied areas of the building to the pick-up station; housing for the on-site containers; and maneuvering space for the collection vehicles. In calculating numbers of containers, assume separate containers for recyclable materials (paper, glass and metals). Waste handling stations must be completely screened by walls and doors or gates constructed of materials complementary to that of the building.

Certain buildings may require additional waste handling equipment such as incinerators or compactors. All incinerator designs must be approved by the Environmental Protection Agency. GSA will coordinate this review.

Flagpoles. See Chapter 2: *Site Planning and Landscape Design, Landscape Design, Landscape Elements*.

Telephone Enclosures. Enclosures for public telephones should be provided in the main lobby, near the cafeteria, near the auditorium and in other building areas serving the public. Accessible public phones must be provided; they must comply with the UFAS/ADA *Accessibility Guidelines* for number, location type and design.

Shelves shall be provided at phone locations, and shall be designed and constructed to accommodate the weight of persons sitting or leaning on them. Assume a 113 kg (250 pound) load per 300 mm (1 foot) of shelf length. In historic buildings where original telephone enclosures exist, reuse original enclosures to the extent possible and design alterations to be visually compatible with original finishes.

Drinking Fountains. At least one water fountain should be provided on every floor near toilet rooms and near auditoria. One drinking fountain per location, and 50 percent of all fountains in the facility, shall be accessible to disabled persons per ADAAG Guidelines. Retain original fountains in historic buildings, retrofitting hardware and remounting, when possible, to provide access for the disabled. Where modifying historic fountains is not practical (e.g., fountain mounted in stone or other ornamental wall), supplement with new fountains of similar materials and detailing to original fountains.

Window Coverings. All GSA buildings should be equipped with adjustable window coverings. Describe the controls for coverings on clerestory and atria windows, and how they will be serviced for cleaning, maintenance, repair and replacement. In some instances it may be possible to consider automated blinds that respond to sun angle and internal temperatures. This may be particularly beneficial in the southern and southwestern areas of the country.

Ronald Reagan Federal Courthouse, Santa Ana, CA

Sculpture, Charles Evans Whittaker Courthouse, Kansas City, MO

Artwork, Signage, and Registry of Designers

Artwork. The process of commissioning art for Federal buildings and courthouses is a collaboration between GSA, the architect of the building, art professionals and community advisors. The Art-in-Architecture Program strives for a holistic integration of art and architecture. Through collaboration – from the initial concept through construction – the artist, architect, landscape architect, engineer, lighting specialist, and practitioners of other disciplines can work as a team to create new expressions of the relationships between contemporary art and Federal architecture. The focus on integrating art with the design of new Federal buildings and courthouses is predicated upon substantial involvement and responsibility of the A/E team. Provisions for cleaning, maintenance and security of the artwork should be coordinated with the Facility Manager.

The Art-in-Architecture project shall begin concurrently with the selection of the A/E and be timed so that the artist(s) have sufficient time to collaborate with the A/E firm on design concepts and that the artist be prepared to discuss their art concept at the Concept Presentation.

Please consult the *Art-in-Architecture Program Guidelines* for additional information.

Fine Arts Program Mission. To manage the portfolio of fine arts assets under GSA's stewardship to insure their accountability, accessibility, preservation and appropriate use to enhance and promote superior workplaces for federal agencies and the public they serve.

Scope of Collection Statement. The Fine Arts Collection includes commissioned public works of art that enhance the architecture of federal buildings; portable works of art commissioned under the federal patronage of the New Deal; works of art purchased with Art in Architecture (AiA) funds; and maquettes. The collection includes over 17,000 installed or associated paintings, sculpture, architectural or environmental works of art, and graphics dating from the 1850's. The collection does not include:

- decorative arts, such as furniture and light fixtures (unless commissioned through the AiA program)
- architectural ornamentation or details, such as historic mosaic flooring, stenciled borders, ceiling medallions, coffered ceilings, cast eagles, and ornamental molding (unless commissioned through the AiA program)
- commemorative works of art, such as busts and portraits
- artwork purchased for office space, such as reproduction prints and posters

Please consult the *Fine Arts Program Desk Guide* for additional information.

Graphics and Signage. Graphics and signs must be clear and simple, and shall be standardized to ensure easy identification of the building entrance, parking, and all the tenant agencies and services located in the building. Signs combining pictures and printed messages are recommended since they are easier to understand for people who do not read English. Sign design shall comply with the UFAS/ADA Guidelines; Underwriters Laboratory (UL) - Illuminated Signs Standard; Occupational Safety and Health Administration (OSHA) Standards for safety signs; and Federal Standard 795 for signs indicating accessibility to the physically challenged. Signage in historic buildings should be compatible with original signage design, using historic finishes, colors, and typefaces as a guide for new signage design. Serif typeface is acceptable within ADA requirements where adequate contrast, scale, and other design factors ensure signage legibility.

Signage must be designed to be adjustable for tenant moves and changes. The specifications shall ensure that GSA will be provided with the equipment and supplies required to make future signage changes.

Registry of Builders and Designers. A plaque shall be placed inside the building with the names of the individuals on the GSA project design team; the consultant architects and engineers; the onsite construction managers; and the construction workers will be inscribed on the plaque. The GSA Project Manager will provide the specifications for the design and construction of the plaque.

3.6 Interior Finishes

Recommended Minimum Standards for Finishes in Tenant Spaces. GSA has set minimum standards for the quality of finishes. GSA provides a tenant improvement allowance for finishes and features within its rental charge. Within this allowance, the choices for interior finishes are the responsibility of the tenant. GSA recommends the following as minimum standards. Where tenants choose finishes below these minimum standards, the tenant is responsible for above standard maintenance costs. Codes may have a bearing on the type of finishes in an area and shall be consulted. For fire safety requirements, see Chapter 7, *Fire Protection Engineering, Interior Finishes*. An example is the need to provide carpet tile rather than continuous carpet over access flooring. Architects are encouraged to select materials of higher quality, within the budget constraints of the project.

Carpets. Carpets should be used in all areas where acoustics are a concern, most notably in office working areas. Carpet tile should be used whenever there is access flooring, a cellular floor, or a ducted floor system, so that maintenance of systems under the floor can be done without destroying the carpet. Carpet tile is available in hard back or cushion back, which maintains its overall appearance longer and is more comfortable to stand and walk on than hard back.

Six-foot-wide (1800mm) cushion back broadloom carpet can be used in many installations. Twelve-foot-wide (3700mm) broadloom carpet without a cushion back or separate pad is appropriate for use in low traffic areas. In high traffic areas, a cushion back or carpet pad should be specified.

Off-gassing is a serious health concern in some carpet installations, as PVC-backed carpet is very common in both carpet tile and six-foot broadloom. It is important that when installing PVC-backed carpet to assure that there are no old adhesives or floor treatments that may react with the PVC, as off-gassing may result. The Carpet and Rug Institute (CRI) has developed the "Green Label" test program to test for off-gassing of carpet, cushion and adhesives. These materials should meet the "Green Label" criteria.

Carpets that use recovered materials shall be specified (see section 3.2, *Special Design Considerations*) and care should be taken to specify carpet that can be recycled in the future. However, when specifying a carpet that complies with RCRA Section 6002 and Executive Order 13101, care must be taken to verify it also meets all the criteria for its intended use and level of foot traffic.

The amount of foot traffic and soiling should be considered when selecting carpet. The CRI has developed test criteria for rating carpet in each of three classifications: severe traffic, heavy traffic, and moderate traffic. A selection of carpet for a lower foot traffic level than anticipated is discouraged.

Severe traffic level – Extreme foot traffic and soiling. Examples are corridors, entrance areas, lobbies, office circulation, food service areas, etc.

Heavy traffic level – Heavy to medium heavy foot traffic and soiling. Examples are private offices, living quarters, open plan office cubicles and workstations.

Moderate traffic level – Moderate foot traffic. Examples are sleeping areas, conference rooms and consultation areas. Commercial grade carpet should be specified for these areas.

A complete list of usage areas and their minimum use classification is available from the Carpet and Rug Institute, PO Box 2048, Dalton, GA 30722

Carpet pattern can mask or camouflage traffic patterns, spots, and soil, so that its appearance will be maintained for a longer period of time. Pattern performance is:

Random pattern design = excellent
Geometric Pattern = good
Tweed = marginal
Solid Color = Poor

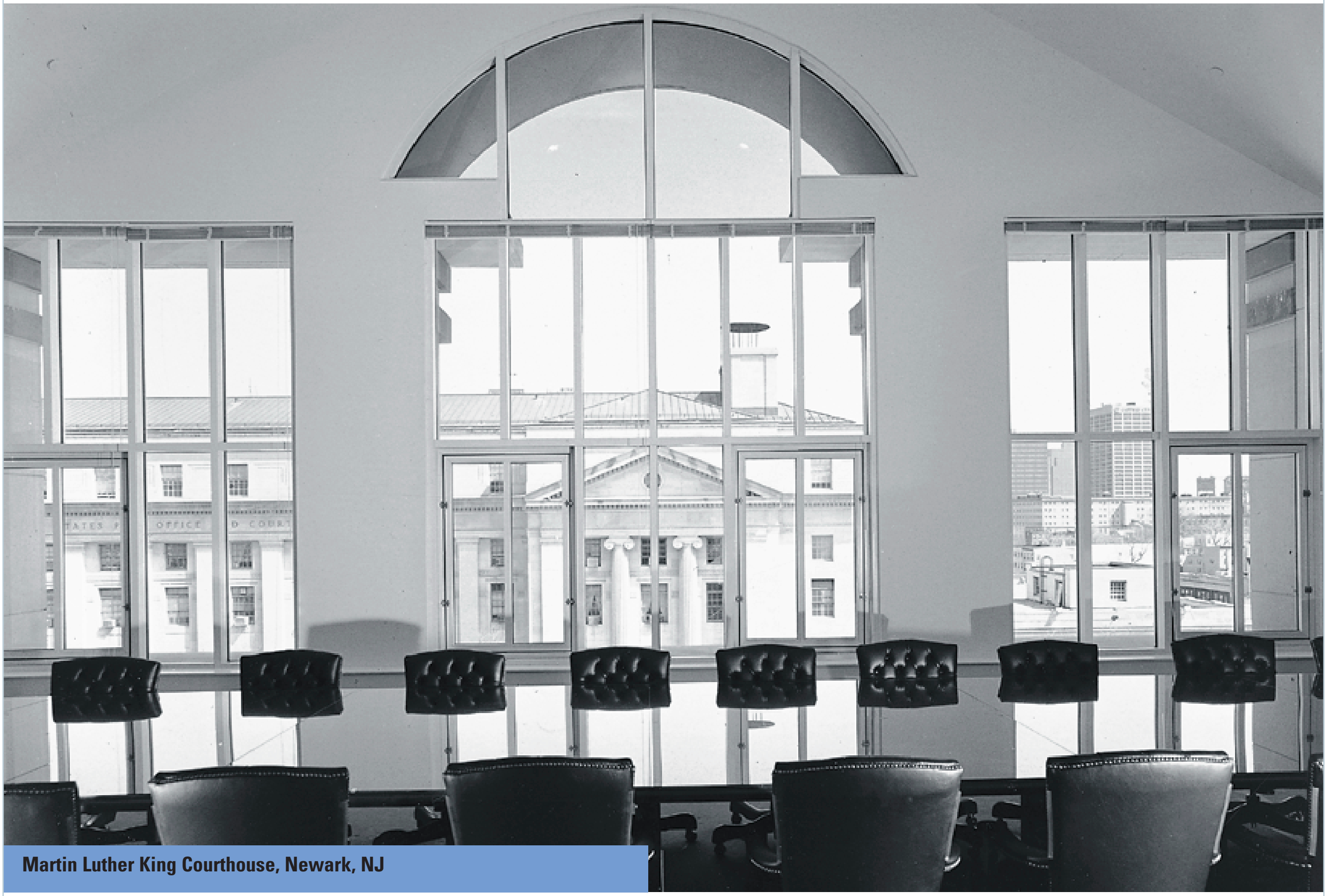
Stains will be the most noticeable when using colors that contrast with soil, dust and spills. Therefore, light and dark colors at the extreme ends of the color spectrum do not perform as well as colors that are in the medium range.

Cushioning carpet adds a shock absorber to the carpet and reduces the crushing of the yarn. This prevents a loss of appearance from creating contrast in the traffic areas, thereby allowing the carpet to provide longer service. It also provides ergonomic benefits by absorbing impact resulting in less stress on the lower legs and feet of the occupants.

Since 80 percent of the soil in the building comes in the entrance areas of the building, it is important to catch the soil at the entry. There are different systems available, including special carpet tiles and entry mats available on GSA Federal Supply Contracts.

Vinyl Wall Covering. The minimum quality of vinyl wall covering is Type II with a minimum finished weight of 620 grams per lineal meter (137 cm average width) (20 ounces per lineal yard with an average width of 54 inches).

Architectural Woodwork. Work under this section should be certified as meeting the referenced standard under the terms and conditions of the AWI Quality Certification Program.


Martin Luther King Courthouse, Newark, NJ

General Office Space (Open and Enclosed Offices)
This category of space comprises a large proportion of area in Federal buildings. Materials, surfaces, and systems must be chosen with quality and flexibility as primary concerns. Office spaces characteristically change with their occupants, occupancy configurations and utility requirements. Interior finishes should allow these transformations to occur with minimal disturbance and cost.

Resilient flooring should only be used in offices adjacent to utilitarian spaces such as loading docks.

Carpet for Raised Access Floor. Carpet tiles should be used on raised access floor. Both carpet adhered to floor panels and loose-laid carpet tile are permitted.

Ceilings. Suspended acoustical materials should be selected for all general office space. Grid size and spacing should be based on the building planning module. Avoid inaccessible ceiling systems.

It is desirable to standardize acoustic ceiling tile within the building as much as possible to minimize the amount of replacement stock. The recommended standard ceiling tile is a commercial quality, 600 mm by 600 mm tegular lay-in (2-foot by 2-foot) tile. See the section *Building Planning, Planning Module* in this chapter.

Doors. The finish for solid core wood doors in general office spaces should be limited to wood veneer. Glass doors may be used at entrances to tenant suites.

Training and Conference Rooms

These areas should be finished at levels of quality equivalent to the adjacent office areas. In addition, the application of tackable acoustic wall panels and rails for the display of presentation materials within these spaces is appropriate.

Internal Corridors

Corridors within general office areas should receive the same finishes as the office areas themselves. Color changes may be useful in these areas for orientation.

Entrances and Vestibules

Entrance lobbies and atria are the focal point of the Federal building. They are the landmark to which all other spaces in the facility relate. They should be an extension of the exterior of the building and the point of transition to interior spaces. These spaces have high levels of visibility and public use and warrant the highest degree of visual detail and finish.

It is desirable to integrate the exterior and interior building design in these areas. Materials shall relate and be of high quality. Choose durable, moisture-resistant materials since these areas are typically exposed to

U.S. Courthouse, White Plains, NY

weather. The depth of vestibules should be no less than 2100 mm (7 feet) to minimize air infiltration.

Floors. All entrance areas require a means to prevent dirt and moisture from accumulating on the entrance lobby floor. It is desirable to have permanent entry way systems (grilles, grates, etc.) to catch dirt and particulates from entering the building at high volume entry ways. Buildings located in areas with severe weather conditions will require more elaborate entry mat and drainage systems to prevent the tracking of melting snow and rain. Buildings located in more moderate climates may require only a natural or synthetic fiber floor mat. The entrance vestibule may also have a hard surface flooring surrounding the matted area that would be part of the adjoining main entrance area.

Doors. Doors at building entrances and vestibules should be glazed to facilitate orientation and safe movement in these high traffic areas.

Elevator and Escalator Lobbies

These elements are functionally related to the public entrance and lobby areas and, therefore, should be treated with the same high finish levels as those spaces. It is appropriate to introduce special floor, wall and ceiling treatments, and special lighting that can be repeated on the upper floors for continuity.

Floors. Elevator and escalator lobbies should harmonize with the finishes used in the entrance lobby or atrium. Because of their importance in orientation and movement, floor treatments in these areas should be similar throughout the building.

Walls. Use durable, high quality surfaces, and coordinate wall finishes with elevator door and frame finishes.

Ceilings. Special treatments are appropriate to visually distinguish elevator lobbies. Avoid completely sealed systems as they make access to elements above the ceiling difficult.

Elevators

Passenger elevators usually receive the highest amount of traffic in the facility. Their finishes should relate to the entrance and lobby areas and should be focal points for the interior design of the building. Although finishes need to be durable, high quality architectural design of cabs and entrances is a priority.

Floors. Elevator floors receive a great amount of wear in a very concentrated area. The flooring surface shall be either extremely durable or easily replaceable. Hard surface floors, such as stone, brick or tile, are usually poor choices because cab floors tend to be unstable. Over time, grouted materials often loosen or crack. Carpet, wood or high quality resilient materials are better choices and perform well acoustically. Carpet materials should be selected for low pile height and high density.

Walls. Wall materials shall present a high quality image and should be sufficiently durable to take some abuse. Materials shall be installed on removable panels or other replaceable devices to facilitate maintenance and renewal of finishes.

Ceilings. Ceilings shall be replaceable. In passenger elevators recessed downlights or indirect fixtures should be used.

Doors. Surfaces should be scratch resistant and easily replaced or refinished. Inside and outside finishes should be coordinated with adjacent wall surfaces.

Freight Elevators. Finishes for freight elevators shall be very durable and easy to clean. Stainless steel walls and doors are preferred. Flooring shall be sheet vinyl or resilient vinyl tile. Ceiling light fixtures must be recessed and protected from possible damage.

Stairways (closed)

General Requirements. Where internal stairways are used for both general vertical circulation and emergency egress, finishes should be consistent with the floors being served by the stair. In stairways used for utility purposes or only for emergency egress, unfinished or minimally finished surfaces are appropriate.

Floors. In general circulation stairs, flooring for stairways, treads, and landings should provide acoustic control. Resilient materials are most appropriate and shall be combined with a non-slip nosing on the treads; these must be non-combustible. These surfaces should be coordinated with materials of the floors, which the stair serves. Utility and egress-only stairs should be of unfinished, sealed concrete or steel. Always provide non-slip nosings.

Walls. Wall surfaces in these areas should be drywall substrate with a simple, straightforward finish such as paint or wall covering. In utility and egress stairs, provide a painted or unfinished surface.

Ceilings. Absorptive materials are desirable in stairways for their acoustic effect. Stair runs should have painted gypsum board soffits where appropriate.

Doors. Doors between adjacent building areas and stairways should match other doors in the building areas. The doors should have the same finish on the interior and the exterior. Utility and egress stair doors should be painted metal.

National Archives, College Park, MD

Stairways (open)

Open stairways that connect lobby and atrium spaces should be appropriately finished in materials that match or relate to the adjacent surfaces in quality and appearance.

Floors. Floor finishes for open stairs should match or coordinate with the adjoining lobby and atrium spaces served by these stairs.

Public Corridors

Floors. Public corridors adjacent to building entrances, atria, etc., which carry significant foot traffic and provide major circulation pathways throughout the building shall have materials selected that shall be extremely durable and require low maintenance. To improve acoustic control in corridors adjacent to work spaces, hard, reflective surfaces should be avoided.

Walls. Walls in public corridors should receive a wall covering over a drywall substrate.

Ceilings. Accessible acoustical ceilings should be selected for corridors. Use a high quality system in public areas. Avoid inaccessible (sealed) ceiling systems. Submit alternative proposals to design team.

Doors. Doors along public corridors should be of a quality equivalent to that of other elements in these spaces and higher quality than those in the interior spaces. Finish may be wood veneer. The finish on both sides of the door should match. At interior spaces with high levels of public use provide glazed entry door systems along public corridors.

3.7 Building Support Spaces

General Use Toilets

Toilets are part of the permanent building core and should be designed with good quality, long-lived finishes. They are an extension of the public spaces of the building. The most appropriate finish for floors and walls in toilet rooms is ceramic or porcelain tile. In light-use areas, less costly moisture-resistant materials may be substituted. In all cases, carefully chosen patterns and colors will enhance the design image.

Continuous vanities of stone, artificial stone, tile or plastic laminate should be designed for lavatories. A large, continuous mirror should be provided on at least one wall of each toilet room. See section 3.2, *Space Planning Requirements*.

Equipment Spaces and Maintenance Shops

Walls and ceilings of all equipment and maintenance shops should be gypsum board, concrete masonry surfaces or other durable surfaces; exposed batt or other forms of insulation should not be used at wall surfaces. Walls in these areas should be painted.

Floors in mechanical rooms and maintenance shops should be waterproofed. Floors in electrical and communications rooms should be painted or sealed. Communications equipment rooms may also have resilient flooring.

Rooms containing major electrical or environmental equipment must be designed to provide clearance for service including replacement of components or the entire piece of equipment.

Staff Locker Rooms and Custodial Spaces

Storage rooms should receive minimal finishes. As in other support areas, these finishes should be coordinated with adjacent spaces. Janitors' closets should be similarly finished, except those containing sinks, which should be provided with a ceramic tile floor and base. Staff locker rooms should be provided with resilient flooring and vinyl wallcovering (or equivalent), except in "wet" areas, which should be finished similar to general use toilets (ceramic tile floor and walls).

Building Engineer's Office and Security Control Center

If theses spaces are included in the building program space requirements, they should be finished like an office. Flooring in the building engineer's office should be vinyl tile if it is located near the central plant or other utilitarian support spaces.

Food Service Areas

Cafeteria Kitchens and Serveries. These areas are operated under concession agreements. Finishes are governed by health regulations and the requirements of the concessionaire. Designers should coordinate their work with the GSA handbook *Concession Management Desk Guide PMFC-93*.

Kitchens Other Than Cafeteria Kitchens. This section describes smaller kitchens typically used by employees. Flooring in these kitchens should be resilient. Walls should have durable, washable finishes such as vinyl wallcovering or ceramic tile, depending on intensity of use. Ceilings should be acoustic material with consideration given to the use of moisture resistant ceiling materials in kitchens with higher humidity.

Other Specialty Areas

Court buildings, border stations, and child care centers have special requirements for finishes. See the *U.S. Courts Design Guide* and Chapter 9: *Design Standards for U.S. Court Facilities* for Court spaces. See the *U.S. Border Station Design Guide (PBS-P130*), and GSA *Child Care Center Design Guide (PBS-P140)* for finishes for these facilities.

3.8 Alterations in Existing Buildings and Historic Structures

The general goal of alteration projects is to meet these facilities standards for new projects. Renovation designs must satisfy the immediate occupancy needs and anticipate additional future changes. As they are remodeled, building systems should become more flexible and adaptable to changing occupancy needs.

Alteration projects are defined at three basic scales: refurbishment of an area within a building, such as a floor or a suite; major renovation of an entire structure; and upgrade/restoration of historic structures.

In the first instance, the aim should be to satisfy the program requirements within the parameters and constraints of the existing systems. The smaller the area in comparison to the overall building, the fewer changes to existing systems should be attempted. Components, equipment and construction should match the existing as much as possible to facilitate building maintenance.

In the second case, the opportunity exists to approximate the standards and flexibility of a new building, within the limits of the existing space and structural capacity.

Where a historic structure is to be altered, special documents will be provided by GSA to help guide the design of the alterations. The most important of these is the Building Preservation Plan (BPP) which identifies zones of architectural importance, specific character-defining elements that should be preserved, and standards to be employed. Refer to pages 1-14 for The Secretary of the Interior's Standards for Rehabilitation and Guidelines for Historic Preservation. For some buildings a Historic Structures Report is also available. Early and frequent coordination between the architect, State Historic Preservation Officer, Regional Historic Preservation Officer, preservation specialists, external review groups, and other appropriate GSA specialists is imperative to timely resolution of conflicts between renovation and preservation goals.

To the extent feasible, GSA seeks to achieve the *rehabilitation* of historic structures. Rehabilitation is defined as the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values.

In general, alterations in historically significant spaces should be designed contextually to blend with original materials, finishes, and detailing, and to ensure a uniform and inviting first impression. When substantial repairs or alterations are undertaken in significant and highly visible locations, opportunities should be sought to restore original features that have been removed or insensitively altered, to reestablish the original design integrity of the space. Alterations affecting the configuration of significant spaces should be as transparent as possible, using glass and contemporary materials, as appropriate, to minimize the visibility of the alteration(s) while subtly distinguishing new construction from original construction.

The architectural, mechanical and electrical systems in historic buildings often differ greatly from today's design and construction standards, and frequently many of these building systems need to be upgraded substantially or completely rebuilt or replaced. The end result should be a

Historic stair, Ariel Rios, Washington, D.C.

building whose architectural, mechanical and electrical systems support its modern use while retaining its historic and architectural character.

Understanding the exact requirements of the user is essential to effectively implement the program for remodel projects. Close interaction between designers and users, to communicate and incorporate program information *during the concept design phase*, will enable the designers to meet the users' needs without incurring excessive construction cost. Practical solutions often develop in a dialogue with the users that would not have been relayed by an administrator.

Alteration design requires ingenuity and imagination. It is inherently unsuited to rigid sets of rules. Each case is unique. The paragraphs that follow should be viewed as guidelines and helpful hints to be used when appropriate and disregarded when not.

Evaluation of Existing Systems

Every alteration project includes an evaluation which describes the physical condition of building systems, identifies variances from present codes, and notes available capacity for structural, mechanical, electrical and communications systems.

Code Requirements for Alterations

For most major renovations an evaluation of code deficiencies is appropriate. See Chapter 1: *General Requirements, Codes and Standards, Building Codes*. Code deficiencies that related to life safety, particularly egress, should be remedied. Strict adherence to the letter of the code is often impossible. An equivalent method of protection will have to be developed to achieve an equal or greater level of safety. See Chapter 1, *General Requirements* for additional information. Architects will be expected to work closely with the GSA regional fire protection engineer who will have final authority on life safety code compliance issues. Alternative approaches outlined in state historic building codes, rehabilitation codes, and performance based codes to resolve conflicts between prescriptive code requirements and preservation goals should be explored.

New work in alterations generally should meet current codes, unless a special hazard is created by combining new and old systems. Such conflicts should be resolved with GSA.

See Chapter 7: *Fire Protection Engineering*, for additional information.

Placing Mechanical and Electrical Systems in Renovated and Rehabilitated Buildings

Finding space for air conditioning, power and communications cabling is one of the biggest design challenges in remodeling work. Existing systems are usually totally inadequate, shafts are too small and ceiling space is too shallow. See Chapter 5: *Mechanical Engineering, Major Alterations in Existing Buildings and Historic Structures* and Chapter 6: *Electrical Engineering, Major Alterations in Existing Buildings and Historic Structures*.

Vertical Distribution. Space for new shafts can sometimes be found in stairwells, if the stairs are larger than required by code. Any element incorporated must have the appropriate fire-resistive construction and not impose on the accessible pathway. If elevator systems need to be replaced, elevator shafts can become duct shafts or electrical closets. The building exterior also offers possibilities if new vertical elements can be integrated with the façade design.

Original elevator doors should be retained. Design for new hoistway and cab doors should be based upon original door detailing, matching original materials and adapting ornamentation as necessary to comply with code.

Original hardware should be maintained in place and upgraded to remain functional wherever possible. Lobby and corridor floor landing indicators should be scaled to avoid destruction of original ornamental finishes, such as borders in stonework designed to frame original indicators.

Horizontal Distribution. Fortunately, many older buildings have tall floor to floor heights, which give the architect two options: a raised access floor or a very deep ceiling space.

Raised Access Flooring is an attractive choice for buildings that are being completely remodeled. Raised flooring can be lower than the minimum of 200 mm (8 inches) indicated for new buildings if floor-to-floor height is insufficient. It offers the same systems quality and flexibility as a new building.

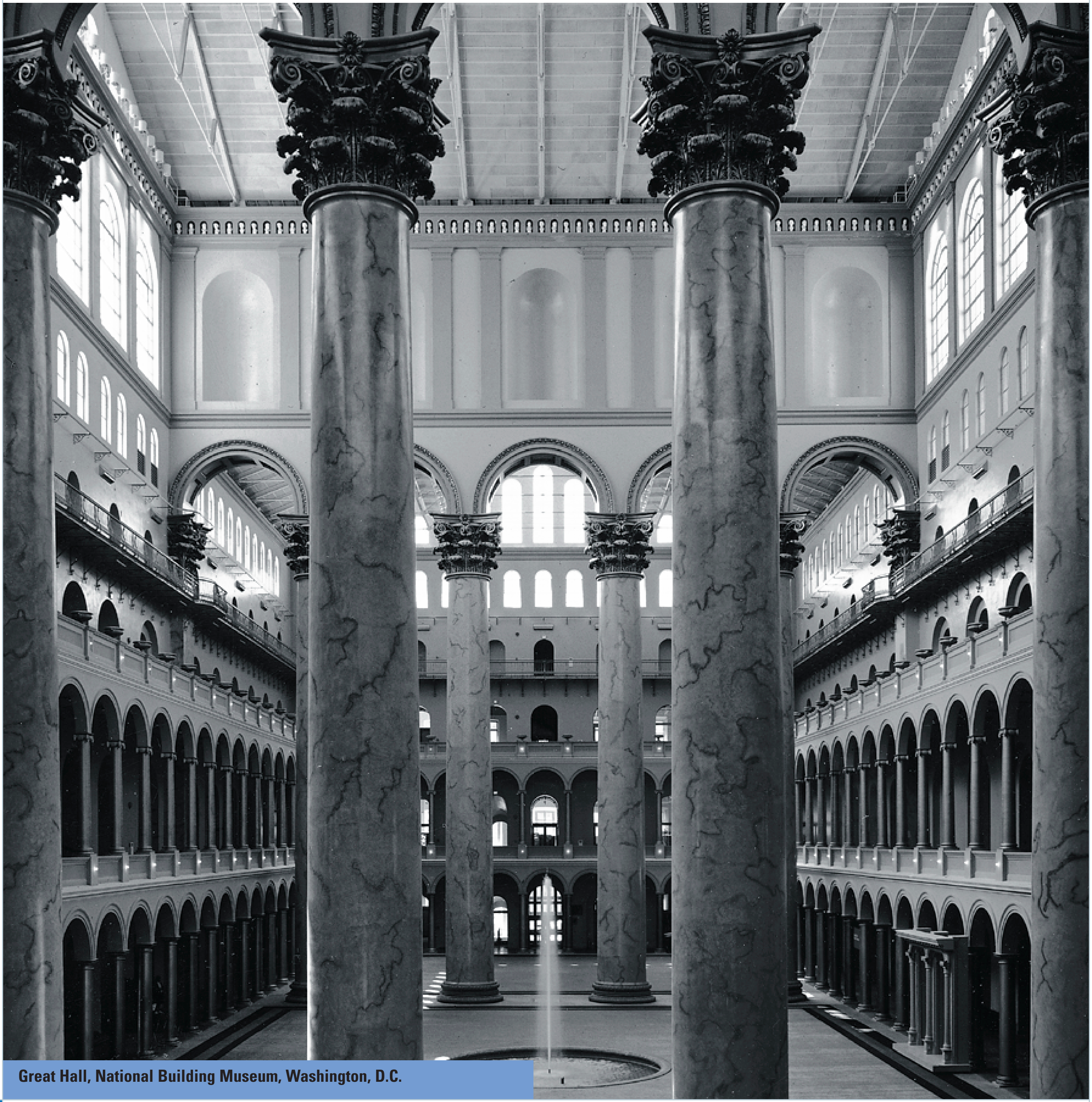
The other option is to create a deep ceiling space and zone it carefully for the most efficient fit of all engineering systems. See section *Building Planning, Planning Module, Floor-to-Floor Heights and Vertical Building Zoning* of this chapter for zoning of ceiling space. Ceilings should never be dropped below the level of the window head. In historic buildings, care should be taken not to allow the installation of dropped ceilings to damage character-defining architectural details and, if possible, to maintain visual access to such details. Carefully designed exposed system installations are encouraged in workspace where exposing systems will a) enable original ornamental ceilings and finishes to remain exposed, b) maintain original high ceiling volume and daylight in new open space offices, or c) avoid disturbing hazardous materials such as asbestos. Exposed systems in historic spaces should be designed to minimize interference with historic details.

In narrow buildings, it may be possible to create a furred horizontal space adjacent to the exterior and core walls, which can be used as a raceway for utilities. Vertical furring on columns and walls for receptacles is another possibility and can be integrated as an architectural feature. If space is tight, all-water or water-and-air systems should be considered for air conditioning, instead of all-air systems.

Utility distribution in historic buildings is the most difficult because ceilings *and* floors often have to be preserved or restored. In these cases, decentralized air conditioning units with little or no ductwork become feasible. Pre-wired systems furniture, which is available in wood, is also a very good solution.

Placement of Main Mechanical and Electrical Equipment. If new equipment is to be placed on the roof, the structural capacity of the framing system must be investigated.

Elevators. For complete building renovations a transportation study should be done, as described earlier in this chapter. If elevators need to be replaced, service can often be improved significantly by selecting higher speed elevators to fit into the existing shafts. New shafts are expensive to build and should be avoided.



Great Hall, National Building Museum, Washington, D.C.

Space Planning Strategies

Office Space. It may be necessary to design a slightly larger space allocation - about 12 m^2 (135 square feet) per person - for office layouts in older buildings. This compensates for less than ideal bay sizes and existing walls configurations. The planning standards described earlier in the section *Space Planning*, should be used as much as possible.

Pre-wired systems furniture may be an appropriate solution for distribution of power and communications wiring in renovated buildings. Open plans have been used successfully in historic buildings. Furniture systems must be selected with great care to minimize any adverse impact on the historic features of the building. Modular furniture system dimensional planning restrictions, best adapted to large open office areas, may have limited feasibility in older structures with short or irregular structural spans.

Food Service. In many older Federal buildings, dining areas are located below grade in cramped, poorly ventilated and poorly lit spaces. Major renovations are a good opportunity to correct this situation. Cost considerations may prohibit moving the kitchen, but light and air can be brought into dining areas by excavating and then glazing to provide views of sunken courtyards outside the dining room.

Acoustics

Office Space. Where existing office space is altered to an open plan, noise isolation of the ceiling system should be a minimum of NIC 20. Noise isolation class between rooms should be NIC 40 in Class B spaces and NIC 35 in Class C space. See the section *Special Design Considerations, Acoustics, Design Criteria for Building Spaces* of this chapter.

Historic Buildings. Hard surfaces often predominate in old buildings and create resonance and echoes. While it may be possible to upgrade the acoustical environment, this should not be done at the expense of the historically significant features of the building.

Alteration of Building Elements

Exterior Closure. See Chapter 4: *Structural Engineering, Alterations in Existing Buildings*. Most older buildings lack adequate insulation and vapor barriers, but these can be added from the inside at the time of alteration. Design alterations to avoid damaging original finishes in preservation zones (as defined in the BPP or HSR).

Refer to *Building Elements* Section of this chapter for references regarding treatment of existing windows.

Exterior masonry should be cleaned if necessary and repointed. Joints should be resealed.

Re-roofing. Where existing roofing is to be replaced, it should be completely removed and the substrate prepared for new roofing. The new roofing system should not be of greater weight than the old, unless a structural analysis shows that the framing system can carry the additional weight. Do not overlay new roofing membrane systems over existing roof membranes. Installing new roofing systems over an existing roof will place additional load on the building structural system and may trap moisture remaining in the original roof. This trapped moisture can facilitate the premature deterioration of the building materials.

Uncommon Products Used In Rehabilitations

In historic preservation it may be necessary to specify uncommon materials that may be hard to find. These products may be described with the supplier's name and address in the specifications. If more than one supplier exists, multiple manufacturers must be stated. The specifications should also contain a note stating: "The use of a trade name in the specifications is to indicate a possible source of the product. The same type of product from other sources shall not be excluded provided it possesses like physical characteristics, color and texture."

New equipment should not be installed on existing materials that are very difficult to adapt for proper connections. These may include: structural glass, marble, and ceramic tile.

3.9 Life Cycle Cost Analysis

All life cycle cost analysis work focusing on particular items should consider the impact on other related systems. In other words, it should be a comprehensive effort balancing the impacts on all aspects of the building design.

Methods for performing life cycle cost analysis are discussed in Chapter 1: *General Requirements, Life Cycle Costing*. This section describes: which architectural and interior systems require life cycle cost analysis: the method to be used for analysis: the number of alternatives to be considered: and the factors to be considered. These requirements vary according to the size and type of building. For individual projects, the Scope of Work may define a different level of analysis than recommended in the *Facilities Standards*.

The following systems are to be analyzed depending on the size of the facility. For each system, the factors relate to scale and complexity, and the number of alternatives to be considered.

Tunnels and Bridges. The analysis should consider the costs of the connection versus staff travel time on alternative circulation routes. Travel time can be based on actual contact information between agencies or on assumptions by the planning team. Other factors that cannot be calculated but should be considered in making the selection include climate conditions; security; and construction challenges. The analysis should be performed when connections are considered for small buildings. It is not necessary to perform analysis on any building with a high security classification or on large buildings.

Exterior Wall Construction and Finishes. The analysis shall consider construction costs, known upkeep, maintenance and replacement costs and schedules, thermal resistance effects on heat loss/gain and first cost impacts to HVAC system designs. Other factors that cannot be calculated but should be considered in making the selection include appearance, the ability to match the finish of expansion areas or replacement panels, resistance to moisture, freezing and ultraviolet light damage, seismic and wind resistance, source and manufacture availability and construction requirements.

Sun Control Devices. The analysis should consider: construction costs; solar gain reduction, HVAC system first costs, operating costs; maintenance and replacement costs; and utility costs compared with not providing sun control devices. As previously stated, sun control also relates to maximizing efficient use of natural daylight in the building.

Exterior Windows. The analysis should consider the construction costs, HVAC system first costs, solar transmission and heat gain and insulation characteristics. Other factors that cannot be calculated but should be considered in making the selection include the affect of color tones on the interior environment, exterior views into the building and security. Analysis should be performed on moderately sized and large buildings considering at least one alternative and at up to three alternatives for very large buildings.

Alternative Roof Systems. In typical projects, a life cycle cost analysis is not required. If a new technology is proposed that has a higher initial costs and probable long term cost savings, then an analysis should be used as part of the decision to utilize the new technology.

Sam Gibbons U.S. Courthouse, Tampa, FL

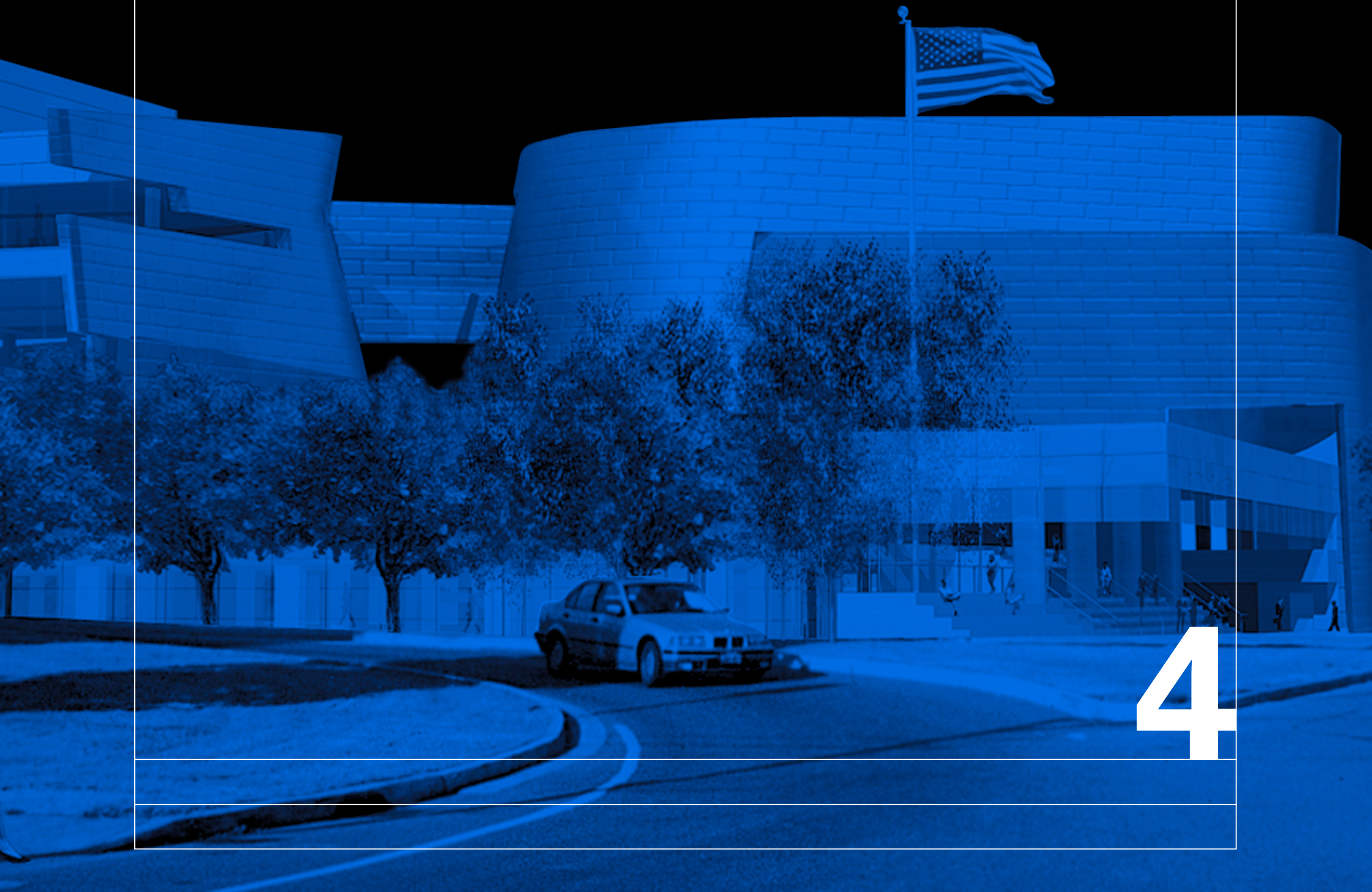
Vincent E. McKelvey Federal Building laboratory wing, Menlo Park, CA

Conveyance Systems. The selection and sizing of elevator and escalator systems must be performed as prescribed in the preceding section *Selecting Conveyance Systems* in this Chapter. No other life cycle cost analysis will be required for conveyance systems.

Interior Wall Systems. The analysis must consider the installation costs including any associated special ceiling, floor, power or communication cabling systems, cost of repairs or refinishing and the percent of the material that can be reused during remodels. The churn factor, or percent of the space disrupted by change within a given year, for space renovation should be established by the GSA region. Other factors that cannot be calculated but should be considered in making the selection include appearance, safety, disruption during moves, manufacturing availability for custom systems, acoustical separation, and security. Analysis should be performed on very large buildings considering at least one alternative.

Interior Protective Finishes. The analysis must consider the installation costs, known cleaning and upkeep costs, known replacement and refinishing costs, any increases in illumination levels because of reflectivity characteristics and remedial acoustical work. Other factors that cannot be calculated but should be considered in making the selection include appearance, safety, disruption during remodeling, ability for the material to be patched, and the release of vapors. The analysis should be performed on finishes covering large areas or high traffic areas.

Structural Engineering



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Eugene, Oregon
Architect: Morphosis
GSA Project Managers: John Bland and Richard Broderick

4.1 General Approach

Three characteristics distinguish GSA buildings from buildings built for the private sector: longer life span, changing occupancies, and the use of a life cycle cost approach to determine overall project cost.

GSA generally owns and operates its buildings much longer than private sector owners. Accordingly, a higher level of durability and serviceability is required for all systems. In terms of structural design, this has resulted in more stringent requirements than those stipulated in model building codes; the floor load capacity requirement of this chapter is an example.

During the life span of a typical Federal building, many minor and major alterations are necessary as the missions of Government agencies and departments change. The capability to accommodate alterations must be incorporated into the building from the outset. In some cases structural systems should be designed to provide some leeway for increase in load concentrations in the future. They should also be designed to facilitate future alterations, e.g., the cutting of openings for new vertical elements, such as piping, conduit and ductwork.

Security is an important consideration in structural design. Refer to Chapter 8: *Security Design* for design criteria related to this matter.

Submission Requirements

Every project will have unique characteristics and requirements for submission and review. The general submission requirements for each phase of project development are described in Appendix A: *Submission Requirements*.

Martin Luther King Courthouse, Newark, NJ

4.2 Codes and Standards

Codes and mandatory standards adopted by GSA for the design of all new buildings are discussed in Chapter 1.

The following FEMA Guidelines shall be incorporated into the structural design for all projects involving new and existing facilities:

- Federal Emergency Management Agency (FEMA) publications:

  Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings (FEMA 350)

  Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings (FEMA 351)

  Recommended Post-earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings (FEMA 352)

  Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications (FEMA 353).

Structural Design of New Buildings

The structural design (including wind, snow and earthquake) of new buildings, structures and portions thereof shall be in accordance with the IBC.

Use of Recycled Materials

The EPA Comprehensive Procurement Guidelines indicate the materials that must contain recycled content in the construction of buildings with federally appropriated funds. (Refer to: Chapter 1, *Recycled-Content Products*.)

Chapter 3, *Incorporation of Recycled-Content Materials* includes a listing of ASTM Specifications for cement and concrete.

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

National Building Museum, Washington, D.C.

4.3 Structural Loads

Design loads shall be in accordance with International Building Code (IBC) except as noted:

GSA promotes flexibility in the use of space. Since corridor locations may not be known until after construction begins and are subject to change over time, use an "office" uniform live load of 3.8 kPa (80 pounds per square foot) in lieu of the tabulated uniform live load in the IBC. Spaces with higher live loads than this should be designed for the code required minimum or the actual live load, whichever is greater. Do not use live load reductions for (1) horizontal framing members, (2) transfer girders supporting columns, and (3) columns or walls supporting the top floor or roof.

Special live load requirements are specified for telecommunications equipment rooms by the EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins).

Telecommunication Closets: Use 3.8 kPa (80 pounds per square foot) minimum distributed live load capacity, which exceeds the minimum live load capacity stated in EIA/TIA Standard 569, standard part 7.2.3 of 2.4 kPa (50 pounds per square foot). Verify if any equipment will be used that exceeds this floor load requirement.

Equipment Rooms for Telecommunication Equipment: Floor loading capacity of telecommunication equipment rooms shall be sufficient to bear both the distributed and concentrated load of installed equipment. The EIA/TIA Standard 569 prescribes a minimum live load capacity for distributed loads of 12.0 kPA (250 pounds per square foot) and a minimum concentrated live load of 4.5 kN (1,000 pounds) over the area of greatest stress to be specified.

Steel bracing in the Milwaukee Courthouse

4.4 Structural Considerations

LRFD and ASD. Both Load Resistance Factor Design (LRFD) and Allowable Stress Design (ASD) are acceptable design procedures for GSA buildings. If LRFD is chosen, the design narrative must specifically address floor vibration.

Cast-in-Place Systems. Systems that have fewer limitations in cutting openings during future alterations are preferred over other systems.

Precast Systems. Precast floor framing systems should only be used for GSA office buildings when the design can be demonstrated to adapt well to future changes in locations of heavy partitions or equipment. Precast systems may be considered for low-rise structures such as parking garages, industrial buildings, and storage and maintenance facilities.

Pre-tensioning and Post-tensioning. As with precast floor framing, these systems should only be used when the design can be demonstrated to not impede future flexibility.

Base Isolation. Base isolation shall be considered for Seismic Design Categories C and D and buildings located in Regions of High Seismicity for two to fourteen story buildings, particularly on rock and firm soil sites which are stable under strong earthquake ground motion. The base isolation system must be shown to be as cost effective as conventional foundation systems. The effects of the base isolation system on the framing, mechanical, and electrical systems shall be included in the evaluation of cost effectiveness.

Passive Energy Dissipation Systems. Passive energy dissipation systems shall be considered for Seismic Design Categories C and D and buildings located in regions of moderate to high-risk seismic zones.

Innovative Mitigation Methods. Innovative mitigation methods that deviate from the requirements of FEMA 356 shall be permitted, provided an analytical procedure acceptable to GSA shows that the required performance level is attained. When new and innovative rehabilitation techniques are proposed for a specific building, a peer review panel, acceptable to GSA, shall determine the adequacy of the mitigation techniques proposed by the engineer.

Progressive Collapse

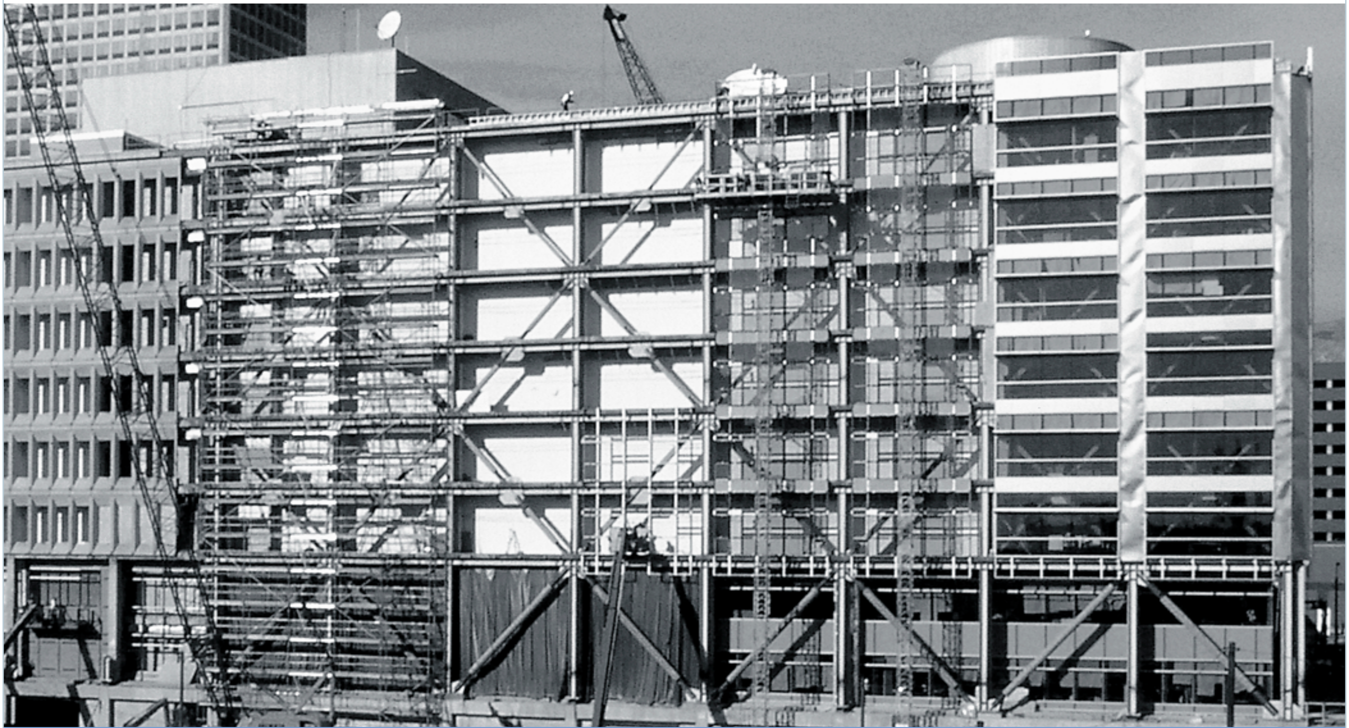
Refer to Chapter 8: *Security Design*.

Floor Vibration

The floor-framing members shall be designed with a combination of length and minimum stiffness that will not cause vibration beyond the "slightly perceptible" portion of the "Modified Reiher-Meister Scale" or an equivalent vibration perception/acceptance criteria.

Seismic Instrumentation for Buildings

For Seismic Design Categories C, D, E, F and buildings located in Regions of High Seismicity, every existing building over six stories in height with an aggregate floor area of 60,000 square feet (5574 m^2) or more, and every building over 10 stories in height regardless of floor area, shall be provided with USGS approved recording accelerographs. USGS developed *guidelines* and a *guide specification* for Federal agencies for the seismic instrumentation



The W.F. Bennett Federal Building in Salt Lake City is the first federal building to use buckling-restrained brace technology.

of their buildings. The *guidelines* describe the locations and the types of instruments used for several "typical" buildings. Typical costs were also developed for existing buildings. The *Seismic Instrumentation of Buildings (with Emphasis on Federal Buildings)*, Special GSA/USGS project, USGS Project No: 0-7460-68170, can be downloaded as a PDF file at **http://nsmp.wr.usgs.gov/celebi/gsa_report_instrumentation.pdf**.

Geotechnical Considerations

The requirements for the geotechnical engineering investigation and report are listed in Appendix A: *Submission Requirements*.

Footings shall not project beyond property lines.

Nonstructural Elements

All nonstructural elements, components and equipment located within a building or on the site must be anchored to withstand gravity, wind, seismic, temperature, and other loads as required by IBC for new buildings and FEMA 356 for existing buildings.

Workmen on the roof of the Winder Building, Washington, D.C. install a window as part of a renovation project.

4.5 Alterations in Existing Buildings and Historic Structures

Alteration requires ingenuity and imagination. It is inherently unsuited to rigid sets of rules, since each case is unique. It is recognized that total compliance with standards may not be possible in every case. Where serious difficulties arise, creative solutions that achieve the intent of the standard are encouraged.

Where a historic structure is to be altered, special documents will be provided by GSA to help guide the design of the alterations. The most important of these is the Building Preservation Plan (BPP) which identifies zones of architectural importance, specific character-defining elements that should be preserved, and standards to be employed. For some buildings a detailed Historic Structures Report is also available. See Chapter 1: *General Requirements*.

General Design Considerations for Structural Upgrading

Seismic Performance. 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.

Evaluation and mitigation of existing GSA buildings shall meet the requirements of ICSSC RP 6 (NISTIR 6762), *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings*. with the following modifications:

- Evaluation of existing buildings shall be in accordance with the provision of the *Handbook for the Seismic Evaluation of Buildings–A Prestandard* (FEMA 310). The primary objective of the Prestandard is to reduce the life-safety risk to occupants of Federal buildings and to the general public. **Life-Safety** is the minimum performance objective appropriate for Federal buildings.

- Seismic rehabilitation of existing buildings shall be in accordance with the provisions of *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 356). **Life-Safety** is the minimum acceptable performance level for existing Federal buildings. FEMA 356 further provides for an extended level of performance, Immediate Occupancy, where required to meet the agency's mission. FEMA 310, *Handbook for the Seismic Evaluation of Buildings–A Prestandard*, and FEMA 356, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, provide the basis for defining these performance objectives, evaluation criteria and if necessary, mitigation, are identified.

  If shown by FEMA 310 evaluation that the desired performance level is not satisfied, the rehabilitation of the building to attain the desired performance level shall substantially satisfy the Basis Safety Objective criteria of FEMA 356, including the use of both the BSE-1 and BSE-2 earthquake criteria.

  It should be noted that the hazard level (ground motion) used in FEMA 310 to evaluate buildings is based on earthquakes with a 2% probability of exceedance in 50 years (2%/50 years). On the other hand, the hazard level used for a rehabilitation design in FEMA 356 is based on compliance with the Basic Safety Objective (BSO). The BSO requires compliance with both the BSE-2 earthquake (2%/50 years earthquake accelerations) at the Collapse Prevention Performance Level and with the BSE-1 earthquake (the lesser of the accelerations from the 10%/50 years earthquake or 2/3 of the 2%/50 years earthquake) at the Life-Safety Performance Level. The earthquake accelerations associated with the 2/3 of the 2%/50 years earthquake will result in significantly higher seismic design values than those resulting from a 10%/50 years earthquake in some areas of the country.

Upgrade Priorities. It may not be practical to upgrade an entire structure to current requirements at any one time. Whenever upgrading is only partially done, the first priority should be given to items that represent the greatest life safety risk, such as the lateral force-resisting system, unreinforced masonry bearing walls or both.

Seismic Upgrades for Historic Buildings. Historic buildings should meet the same life safety objective as other buildings. Decisions made to preserve essential historic features should not result in a lesser seismic performance than that required by ICSSC RP 6. See Chapter 1.

Seismic Strengthening Criteria for Nonstructural Elements. Where deficiencies in the attachment of elements of structures, nonstructural components and equipment pose a life safety risk, they should be prioritized and those elements with the greatest life safety risk strengthened first to meet current code requirements.

4.6 Seismic Requirements for Leased Buildings

New Construction

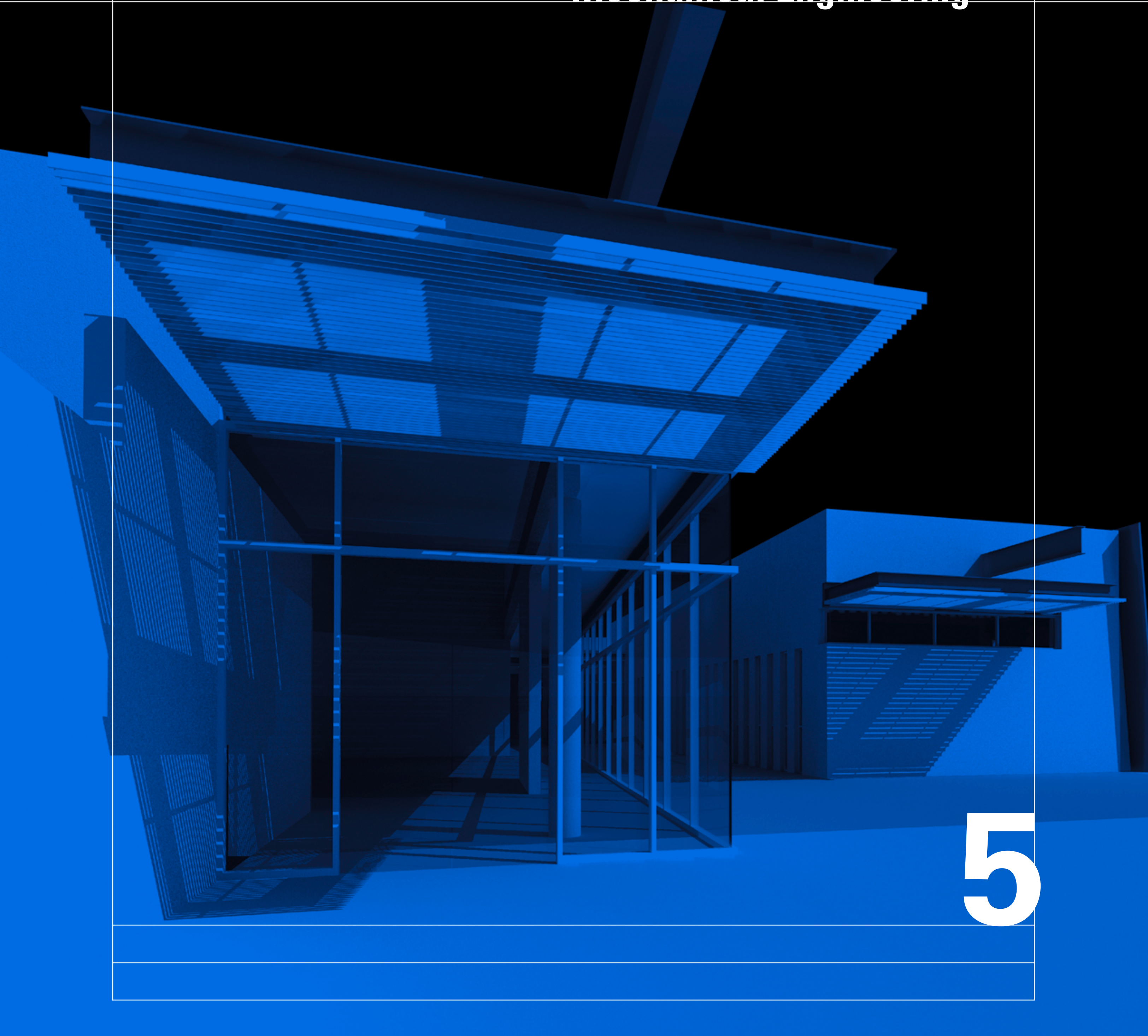
New buildings or the construction of an addition to an existing building shall conform to the IBC. For information see the latest edition of GSA's Solicitation for Offers (SFO).

Existing Buildings

Existing buildings shall meet the seismic requirements of the *Standards of Seismic Safety for Existing Federally Owned or Leased Building and Commentary*, ICSSC RP 6, as modified by the latest edition of GSA's Solicitation for Offers (SFO).

ICSSC RP 6 can be downloaded as a PDF at **http://fire.nist.gov/bfrlpubs/build01/PDF/b01056.pdf.**

Mechanical Engineering



5

5.0 TABLE OF CONTENTS

Temecula Border Patrol Station, Murietta, California
Architect: Garrison Architects
GSA Project Manager: Steve Baker

5.1 General Requirements

This chapter identifies criteria to program and design heating, ventilating and air conditioning (HVAC) and plumbing systems.

Mechanical systems must be coordinated and integrated with the designs of other involved/impacted building systems and features. As addressed in the Appendix, mechanical systems shall be adapted to support all performance objectives, typically involving sustainability, workplace performance (productivity and efficiency), fire safety, security, historic preservation, and improved operations and maintenance.

Mechanical systems shall be specifically designed to function at full load and part load associated with all projected occupancies and modes of operation. To the maximum extent possible, system solutions shall also accommodate planned future occupancies and modes of operation. (Special emphasis shall be placed on the design considerations for U.S. Court Facilities to allow for renovation, relocation, and creation of new Courtrooms and adjunct facilities or retrofitting Courtroom facilities for other Agencies' use. See Chapter 9, "*Design Standards for U. S. Court Facilities,*" for design criteria.)

The design of the mechanical systems shall generally be more demanding in performance expectations than represented within *ASHRAE 90.1* and *10 CFR 434* standards. All mechanical systems shall be designed to automatically respond to the local climatic conditions and heat recovery opportunities to provide cost effective energy conservation measures while assuring set point control. The design of mechanical systems and other building components shall all combine together to produce a building that meets the project's programmed sustainability rating (LEED rating) and assigned energy target, as referenced in Chapter 1.

Maintainability and reliability are major concerns in the operation of Federal buildings. As such, the design and installation of all mechanical equipment and components shall allow for removal and replacement, including major equipment such as boilers, chillers, cooling towers, pumps and air-handling equipment.

Standby capacity shall be designed into mechanical systems, enabling continuous services during repair or replacement of a failed piece of equipment or component. Redundant equipment shall typically not be designed into systems as "stand-by" units but rather shall be used as part of the operating system with equal time cycling through automatic control sequencing.

Proposed systems and equipment will be evaluated by GSA for their offerings of advanced technology; however, GSA does not allow use of experimental, unproven, or proprietary equipment or systems. Documented proof of historical capability and adaptability of all equipment and systems proposed for a project shall be made available to GSA.

As indicated herein, the description of the mechanical baseline systems establishes the minimum level of quality, function, and performance that may be considered.

Submission requirements are addressed in Appendix A.3.

5.2 Codes

Mechanical Codes

As stated in Chapter 1, *General Requirements, Codes and Standards, Building Codes*, facilities shall comply with the ICC's International Mechanical Code and the International Plumbing Code.

5.3 Standards

Mechanical Design Standards

The latest editions of publications and standards listed here are intended as guidelines for design. They are mandatory only where referenced as such in the text of this chapter or in applicable codes. The list is not meant to restrict the use of additional guides or standards. When publications and standards are referenced as mandatory, any recommended practices or features shall be considered "required." When discrepancies between requirements are encountered, GSA shall determine the requirement.

- *ASHRAE: Handbook of Fundamentals.*
- *ASHRAE: Handbook of HVAC Applications.*
- *ASHRAE: Handbook of HVAC Systems and Equipment.*
- *ASHRAE: Standard 15: Safety Code for Mechanical Refrigeration.*
- *ASHRAE: Standard 52: Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.*
- *ASHRAE: Standard 55: Thermal Environmental Conditions for Human Occupancy.*
- *ASHRAE: Standard 62: Ventilation for Acceptable Indoor Air Quality.*
- *ASHRAE: Standard 90.1: Energy Standard for Buildings Except Low-Rise Residential Buildings.*
- *ASHRAE: Standard 100: Energy Conservation in Existing Buildings.*
- *ASHRAE: Standard 105: Standard Method of Measuring and Expressing Building Energy Performance.*
- *ASHRAE: Standard 111: Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC Systems.*

- *ASHRAE: Standard 114: Energy Management Control Systems Instrumentation.*
- *ASHRAE: Standard 135: BACnet: A Data Communication Protocol for Building Automation and Control Networks.*
- *ASHRAE: Guideline #4: Preparation of Operating and Maintenance Documentation for Building Systems.*
- American National Standards Association: *ANSI Z 223.1.*
- *National Fuel Gas Code Standard 54.*
- American Society of Mechanical Engineers: *ASME Manuals.*
- American Society of Plumbing Engineers: *ASPE Data Books.*
- Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA):
- *ASHRAE HVAC System Duct Design.*
- *SMACNA HVAC Duct Construction Standards: Metal and Flexible.*
- *SMACNA HVAC Air Duct Leakage Test Manual.*
- *SMACNA Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.*
- *Seismic Restraint Manual Guidelines for Mechanical Systems.*
- NFPA Standard 96
- All applicable regulations and requirements of local utility companies having jurisdiction.
- EIA/TIA Standard 569: *Commercial Building Standard For Telecommunications Pathways And Spaces* (and related bulletins).

5.4 Program Goals

Design Integration

As represented in Appendix A-2, mechanical systems must be selected to routinely address multiple program goals, including: workplace performance, sustainability, energy efficiency, security, fire safety, historic preservation and operations/maintenance concerns, as well as other project expectations. Design solutions shall not sacrifice the basic needs of one program area to optimize another. Instead, mechanical designs must optimize program areas to the extent possible, assuring attainment of all critical performance goals. Prior to making any mechanical systems solutions, their designer shall visit the Whole Building Design Guide website, **www.wbdg.org,** to identify program goal principles and to consider available technologies.

Life Cycle Costing

Life cycle cost analysis shall comply with requirements addressed in Chapter 1. This includes consideration of analysis period, escalation discount rates, and other parameters. The indicated software program, "Buildings Life Cycle Cost", is recommended when used with provisions that support "Federal Analysis—Projects Subpart to OMB A-94 Guidelines."

The baseline HVAC systems described in the following section set minimum system requirements and act as a reference from which advantages and disadvantages of other systems or sub-systems can be compared.

Any deviation from the GSA defined baseline standards or from the directives described herein shall not be permitted unless previously identified in project programming requirements, and submitted directly to and subsequently authorized by the Office of the Chief Architect.

5.5 HVAC Baseline Systems

Baseline Selection

Unless otherwise directed in design programming documents, a combination of the following perimeter and interior HVAC systems shall be used to set a base reference for comparison.

Perimeter Systems. Perimeter zones shall have 100-percent outside air dedicated ventilation systems sized to meet the ventilation requirements of the specified zone. These systems shall provide tempered dehumidified air and shall be completely independent of any other air distribution system. In addition to the dedicated 100-percent outside air ventilation system(s), the perimeter zones shall also have a baseline perimeter heating and cooling system selected from the following:

- For new construction spaces with significant latent loads and/or for alterations to existing space with ceiling distribution, use a ducted overhead variable air volume (VAV) air distribution system with VAV shutoff boxes for cooling and hot water fin-tube systems for heating.
- A ducted overhead variable air volume (VAV) air distribution system with fan-powered VAV boxes with hot water heating coils for cooling and heating.[1]
- For new construction office type loads and other spaces with low latent loads, use an underfloor, variable air volume (VAV) air distribution system, for cooling, supplemented with two-pipe, above floor perimeter hot water fin-tube systems for heating.
- For alteration projects with high skin loads use a standard four-pipe fan coil unit system for heating and cooling.

Interior Systems. Interior zone(s) shall have 100 percent outside air ventilation system(s) to meet the ventilation requirements of the interior zone. The ventilation system(s) shall operate independently of any other air distribution system but shall connect to the return side of the VAV air-handling unit(s) serving the interior zone(s). The interior zone(s) shall also have a baseline interior heating and cooling system selected from the following:

- A ducted overhead variable air volume (VAV) system with VAV boxes.
- A ducted overhead variable air volume (VAV) system with fan-powered VAV boxes.[2]
- An underfloor variable air volume (VAV) air distribution system.

[1] Electric heating coils will be permitted for nominal heating requirements. Requests for use of electric heating coils must be submitted directly to and subsequently authorized by the office of the Chief Architect. No reheat is permitted.

[2] Hot water heating coils in the fan-powered VAV boxes may be used on the top floor of a building for heating.

General

- Enthalpy heat recovery shall be used for interior zones and other special areas where the outside air exceeds 30 percent of the total supply air quantity.
- Special areas such as auditoriums, atriums, and cafeterias shall have a dedicated air-handling unit with individual controls to condition these spaces as required.
- A dedicated air-handling unit shall be provided for maintaining positive pressure in the main entry lobby.
- Air-handling units with a capacity over 1,416 LPS (3,000 CFM) shall have an enthalpy economizer cycle. Systems dedicated to serving only unoccupied spaces with intermittent operation, such as elevator machine rooms, telephone equipment rooms and similar spaces would be exempt from the requirements of having an economizer cycle.
- Waterside economizer system shall be employed where airside enthalpy economizer is not practical or feasible. Systems dedicated to serving only unoccupied spaces with intermittent operation, such as elevator machine rooms, telephone equipment rooms and similar spaces would be exempt from the requirements of having an economizer cycle.

5.6 Design Criteria

General Parameters

HVAC system parameters are provided here for reference, but specific energy performance directives are also listed in 10 CFR 434. Compliance with the latest versions of *ASHRAE Standard 90.1* and *ASHRAE Standard 62* is required for the elements of the project (architectural, mechanical, and electrical).

Outdoor Design Criteria

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 99.6 percent column dry bulb temperature in the *ASHRAE Fundamentals* Volume. Summer design conditions for sensible heat load calculations shall be based on the 0.4 percent dry bulb temperature with its mean coincident wet bulb temperature. Design conditions for the summer ventilation load and all dehumidification load calculations shall be based on the 0.4% dew point with its mean coincident dry bulb temperature.

Indoor Design Criteria

Indoor Design Temperatures and Relative Humidity. Indoor design temperatures and relative humidity requirements are stated in Table 5-1. The following spaces shall be kept under negative pressure relative to surrounding building areas: smoking lounge, detention cells, toilets, showers, locker rooms, custodial spaces, battery charging rooms, kitchens and dining areas. Air can be returned from the dining area space. The air from these spaces must be exhausted directly to the outdoors.

Building Pressurization. To keep dry air flowing through building cavities, systems shall be designed with sequence of operations that assure continuous positive pressure with respect to the outdoor environment until the outdoor temperature falls below 4.5°C (40°F), when the building pressure shall be brought to neutral. These building HVAC systems shall have an active means of measuring and maintaining this positive pressure relationship. The BAS shall alarm when the building pressurization drops below a predetermined low limit. In areas where exhaust systems are used or an indoor air quality contaminant source is located, a negative pressure shall be maintained relative to surrounding spaces. Calculations shall be provided that show the minimum outside airflow rate required for pressurization. Minimum outside airflow rates shall be adjusted as necessary to assure building pressurization.

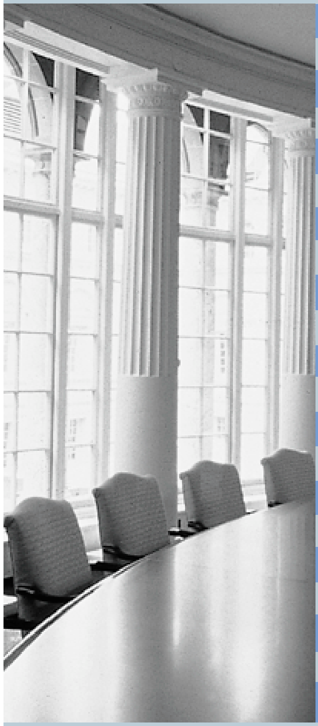
Artwork. In general, it is important to keep within an RH range of 30 to 70%. In a hot and dry geographic region it makes sense to maintain a range that errs on the low side (20 to 40%), while in semitropical climates a range of 55 to 75% may be practical.

Please consult Chapter 4.1, Installation Standards, of the *Fine Arts Program Desk Guide* for additional information.

Energy Analysis. An energy analysis of building characteristics, the mechanical and electrical components, and all other related energy consumption elements must be performed for each design submission level project as described in Appendix A.3.

Analyses of energy-conserving designs shall include all relevant facets 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 building automation equipment to automatically adjust for building partial occupancies, optimized start-stop times and systems resets. Energy analysis shall utilize public domain DOE-2 programs. Inputs and outputs shall follow *ASHRAE 90.1 Standards* and *10 CFR 434*.

Table 5-1
Indoor Design Conditions[3]



Type of Area	Summer DB[1]	Summer RH[2]	Winter DB[1]	Winter RH[2]
General Office	24 (75)		22 (72)	
ADP Rooms[9]	22 (72)	45[4]	22 (72)	
Corridors	24 (75)		22 (72)	
Building Lobbies[10]	24 (75)		22 (72)	
Toilets	24 (75)		22 (72)	
Locker Rooms	26 (78)		21 (70)	
Electrical Closets	26 (78)		13 (55)	
Mech. Spaces	35 (95)[5]		13 (55)[8]	
Elec. Switchgear	35 (95)[5]		13 (55)	
Elevator Mach. Room[10]	26 (78)[5]		13 (55)	
Emerg. Gen. Room	40 (104)[6]		18 (65)	
Transformer Vaults	40 (104)[5]			
Stairwells	(none)		18 (65)	
Comm./Tel. Frame Room[7]	24 (75)	45	22 (72)	30[12]
Storage Room	30 (85)		18 (65)	
Conference Room[11]	24 (75)		22 (72)	
Auditorium[10]	24 (75)		22 (72)	
Kitchen[10]	24 (75)		22 (72)	
Dining[10]	24 (75)		22 (72)	
Cafeteria[10]	24 (75)		22 (72)	
Courtrooms	24 (75)		22 (72)	454*

*Requires humidification in the winter.

Notes:

1 Temperatures are degrees Celsius (Fahrenheit), to be maintained at +/-1 °C (+/-2 °F).
2 Relative humidity is minimum permissible, stated in percent. Maximum permissible relative humidity is 60 percent in conditioned areas.
3 Dry bulb and relative humidity are to be maintained 150 mm (6 inches) to 1800 mm (6 feet) above the floor.
4 Relative humidity should be maintained at +/-5 percent in ADP spaces.
5 Maximum temperature. Space to be mechanically cooled if necessary.
6 Room must not exceed temperature with generator running.
7 Must comply with EIA/TIA Standard 569.
8 Minimum temperature in the building must be 13 °C (55 °F) even when unoccupied.
9 Confirm equipment manufacturer 's requirements as more stringent. Provide in-room display and monitor device (such as wall mounted temperature and humidity chart recorder),
10 System shall be designed for process cooling. Cooling system shall be a dedicated independent system.
11 Provide independent temperature control.
12 Minimum relative humidity requirements may be omitted in moderate southern climate zones upon approval of local GSA representatives.

Table 5-2
Air Intake Minimum Separation Distances

Object	Minimum Distance m	ft
Property line	1	3
Garage entry, loading dock	7	25
Driveway, street or public way	3	10
Limited access highway	7	25
Grade	14	50
Roof*	0.5	1
Cooling tower or evaporative condensers	5	15
Exhaust fans and plumbing vents	3	10
Kitchen supply and exhaust air	7	25

* Roof intakes must be at least 0.2 m (8 inches) above the average maximum snow depth and the potential for drifts at the intake location must be considered. Outdoor intakes should be covered by 13 mm (0.5 inch) mesh screen. The screen should be of corrosion-resistant material and located outside of or no more that 0.2 m (8 inches) inside of the outside face of the intake grille, louver, or rain hood entry. On buildings of more than four stories the outside air supply louvers shall be located on the fourth level of the building or higher. On buildings of three stories or less, locate the intakes on the roof or as high as possible. Locating intakes high on the exterior wall is preferred to a roof location. Outside air intake is not permitted within seven meters (twenty-five feet) of loading dock or any other fume producing areas.

Air Intake and Exhaust. The placement and location of outside air intakes is critical to the safety of the occupants inside a building and must be in compliance with the security requirements of the building, as described in Chapter 8, "*Security Design.*" Table 5-2 provides a guide for minimum separation distances between ventilation air intakes and other building features.

Indoor Air Quality. When a building is new, volatile compounds (VOC) may be released in large quantities from materials, such as adhesives, vinyl and carpets. An outside air purge cycle shall be provided to air-handling equipment enabling evening removal of VOC build-ups during the first weeks of occupancy.

GSA recognizes the importance of adequate ventilation to maintain indoor air quality. The outside air and ventilation rates of *ASHRAE Standard 62* are the minimum acceptable in GSA buildings. Instrumentation and controls shall be provided to assure outdoor air intake rates are maintained within 90 percent of required levels during occupied hours.

Where occupancy requirements are likely to generate high levels of airborne particles, special air filtration shall be provided on the return air system or dedicated and localized exhaust systems shall be utilized to contain airborne particulates.

Dilution with outside air is the primary method of maintaining acceptable indoor air quality. The site shall be surveyed to determine if there are airborne sources of contaminants that may be unacceptable for use indoors with respect to odor and sensory irritation.

Internal Heat Gain

Occupancy Levels. For office spaces, the average density of the *occupiable floor area* of a GSA building is one person per 9.3 usable square meters (100 usable square feet). Within areas occupied by workstations, the occupancy load can be as dense as one person per 7 usable square meters (75 usable square feet) in local areas. Block loads and room loads should be calculated accordingly. Sensible and latent loads per person should be based on the latest edition the *ASHRAE Handbook of Fundamentals.*

For dining areas, auditoriums and other high occupancy spaces, occupancy loads should represent the number of seats available. Areas such as storage rooms or mechanical rooms do not have occupancy loads.

Equipment Densities. Internal heat gain from all appliances—electrical, gas, or steam—should be taken into account. When available, manufacturer-provided heat gain and usage schedules should be utilized to determine the block and peak cooling loads. Typical rate of heat gain from selected office equipment should be based on the latest edition of the *ASHRAE Handbook of Fundamentals.* The cooling load estimated for the connected electrical load should be based on the electrical load analysis, and the estimated receptacle demand load outlined in Chapter 6, "*Electrical Engineering, Electrical Load Analysis,*" and anticipated needs of GSA's Office of Chief Information Officer. For printers and personal computers, 80 percent diversity shall be considered.

Lighting Levels. For preliminary design loads, heat gain from lighting levels described in Chapter 6: "*Electrical Engineering, Lighting, Interior Lighting, Illumination Levels,*" shall be used.

Zoning Criteria

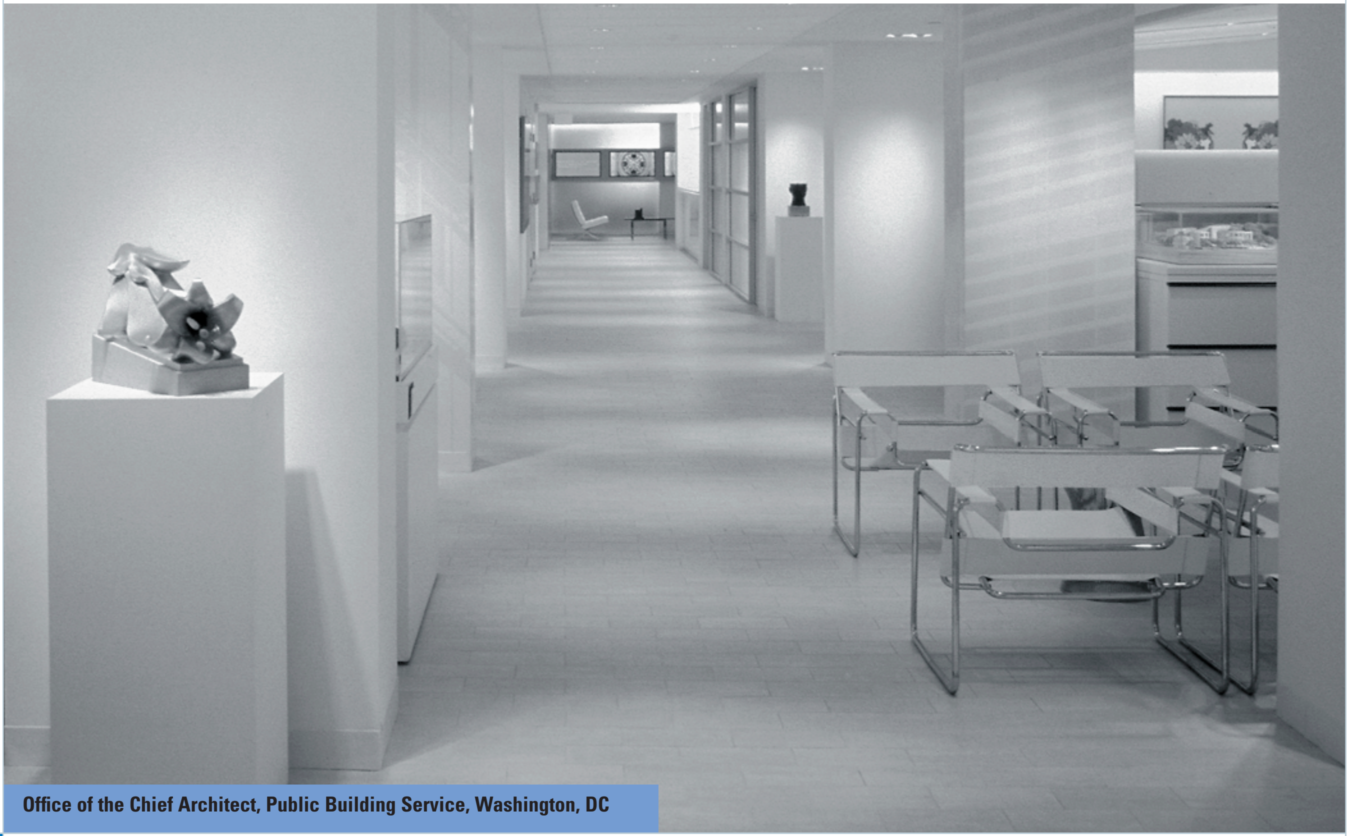
Separate systems shall be provided for interior and perimeter zones where simultaneous heating and cooling operations may occur.

Single air handling units shall not serve multiple floors or scattered building loads. Multiple air handling units or floor-by-floor systems shall be considered as baseline. Systems designed for federal courthouses shall be limited to having no more than two courtrooms served by any single air handling unit, and that air handling unit shall be dedicated to serving only those two courtrooms.

Interior control zones must not exceed 180 m^2 (1,500 sf) per zone for open office areas or a maximum of three offices per zone for closed office areas. Corner offices shall be a dedicated zone. Perimeter zones shall be no more than 4.7 meters (15 feet) from an outside wall along a common exposure. Independent zones should be provided for spaces such as conference rooms, entrance lobbies, atriums, kitchen areas, dining areas, childcare centers and physical fitness areas. Perimeter zones shall not exceed 30m^2 (300 sf).

If a building program shows that an office building will have an open plan layout or if the program does not state a preference, it may be assumed that up to 40 percent of the floor plan will be occupied by closed offices at some point in the future.

The supply of zone cooling and heating shall be sequenced to prevent (or at the very least, minimize) the simultaneous operation of heating and cooling systems for the same zone. Supply air temperature reset control shall be utilized to extend economizer operations and to reduce the magnitude of reheating, recooling or mixing of supply air streams.



Office of the Chief Architect, Public Building Service, Washington, DC

5.7 Arrangement of Mechanical Spaces

Minimum Space Requirements. A minimum of 4 percent of the typical floor's gross floor area shall be provided on each floor for air-handling equipment. A minimum of 1 percent of the building's gross area shall be provided for the central heating and cooling plant (location to be agreed upon during preparation of concept submission. Space requirements of mechanical and electrical equipment rooms shall be based upon the layout of required equipment drawn to scale within each room.

Service Access. Space shall be provided around all HVAC system 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-site 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. The HVAC design engineer should be cognizant of the necessity to provide for the replacement of major equipment over the life of the building and should insure that provisions are made to remove and replace, without damage to the structure, the largest and heaviest component that cannot be further broken down.

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 that have maintenance service requirements.

Vertical Clearances. Main mechanical equipment rooms generally shall have clear ceiling heights of not less than 3.6 m (12 feet). Catwalks shall be provided for all equipment that cannot be maintained from floor level. Where maintenance requires the lifting of heavy parts [45 kg (100 pounds) or more], hoists and hatchways shall be installed.

Horizontal Clearances. Mechanical rooms shall be configured with clear circulation aisles and adequate access to all equipment. The arrangement shall consider the future removal and replacement of all equipment. The mechanical rooms shall have adequate doorways or areaways and staging areas to permit the replacement and removal of equipment without the need to demolish walls or relocate other equipment. Sufficient space areas (noted by outlining manufacturer's recommendations) for maintenance and removal of coils, filters, motors, and similar devices shall be provided. Chillers shall be placed to permit pulling of tubes from all units. The clearance shall equal the length of the tubes plus 600 mm (2 feet). Air-handling units require a minimum clearance of 750 mm (2 feet 6 inches) on all sides, except the side where filters and coils are accessed. The clearance on that side should equal the length of the coils plus 600 mm (2 feet).

Roof-Mounted Equipment. No mechanical equipment except for cooling towers, air-cooled chillers, evaporative condensers, and exhaust fans shall be permitted on the roof of the building. Access to roof-mounted equipment shall be by stairs, not by ship's ladders.

Housekeeping Pads. Housekeeping pads shall be at least 150 mm (6 inches) wider on all sides than the equipment they support and shall be 150 mm (6 inches) thick.

Mechanical equipment rooms must be designed in accordance with the requirements of *ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.*

5.8 Mechanical Requirements for Special Spaces

United States Courthouse, White Plains, NY

Courtrooms. Generally, each Courtroom and its respective ancillary areas coupled to the operation of the Courtroom shall constitute a primary zone. No more than two Courtrooms and their respective ancillary areas shall be supplied from the same air-handling unit and system. Refer to the *U.S. Courts Design Guide* published by the Administrative Office of the United States Courts (AOC) for specific requirements.

Auditoriums. Auditoriums shall have dedicated air-handling units equipped with enthalpy economizer cycle. Units shall be designed with 80 percent diversity factor to maintain necessary temperature and humidity conditions under partial loads and partial occupancy. Provide dewpoint control. Dewpoint of supply air shall not exceed 10°C (50°F) dry bulb.

U.S. Marshals Service Areas. The U.S. Marshals Service area HVAC system shall be designed for continuous operation and shall be independently controlled and zoned. All ductwork and air circulation openings penetrating the secure area envelope, including prisoner circulation areas, shall be provided with security bars. Detainee holding areas shall be negatively pressurized with regard to adjacent spaces and exhausted directly to the outdoors. Refer also to requirements of USMS Publication 64.

Firing Range. Special HVAC considerations will be required for firing ranges. A firing range shall be provided with a dedicated air-handling system. Heating and cooling supply air shall be delivered to the area along and behind the firing line for occupant comfort conditions and to maintain a positive pressure in this area relative to down range and target area. Powered exhaust air shall be extracted from down range and the target areas in sufficient quantity to remove smoke and maintain a clear line of vision to the target. Sixty percent of the total exhaust shall be extracted at a point approximately one-third the distance from the firing line to the target area, and forty percent shall be extracted from above the target area. All exhaust air shall be filtered to preclude the emission of lead particulates and gunpowder residue into the atmosphere. Discharge of firing range exhaust air to outdoors shall be carefully located to prevent recirculation into the outside air intake of any HVAC system. Firing range systems shall be capable of continuous operation, isolated from other building systems.

Kitchens and Dishwashing Areas. Kitchens with cooking ranges, steam kettles, ovens and dishwashers shall be provided with dedicated make-up air and exhaust hoods/exhaust systems in accordance with latest edition of *NFPA Standard 96* and *ASHRAE Applications Handbook.* All components of the ventilation system shall be designed to operate in balance with each other, even under variable loads, to properly capture, contain, and remove the cooking effluent and heat, and maintain proper temperature and pressurization control in the spaces efficiently and economically. The operation of the kitchen exhaust systems should not affect the pressure relation between the kitchen and surrounding spaces. Both supply air and makeup air shall be exhausted through the kitchen hood heat recovery system while a maximum of 30 percent of the exhaust air is made up from the space.

Floor drains must be provided at each item of kitchen equipment that requires indirect wastes, where accidental spillage can be anticipated, and to facilitate floor-cleaning procedures. Drains to receive indirect wastes for equipment should be of the floor sink type of stainless construction with a sediment bucket and removable grate.

Areas of Refuge. The area of refuge provided for the Judiciary in the event of emergency conditions shall be provided with adequate ventilation energized from the emergency power distribution system and sufficient heating capacity to maintain space temperature of 21°C (70°F) with design winter outdoor temperature. Provide separate air-handling unit to maintain positive pressure, relative to surrounding spaces, with heating-cooling coils and differential pressure sensing system.

Mechanical Rooms. All mechanical rooms must be mechanically ventilated to maintain room space conditions as indicated in *ASHRAE 62, ASHRAE 15,* and Table 5-1 of this chapter. Water lines shall not be located above motor control centers or disconnect switches and shall comply with requirements of *NEC* Chapter 1. Mechanical rooms shall have floor drains in proximity to the equipment they serve to reduce water streaks or drain lines extending into aisles.

Chiller Equipment Rooms. All rooms for refrigerant units shall be constructed and equipped to comply with *ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.* Chiller staging controls shall be capable of DDC communication to the central building Energy Management System.

Electrical Equipment Rooms. No water lines are permitted in electrical rooms, except for fire sprinkler piping. Sprinkler piping lines must not be located directly above any electrical equipment.

Communications Closets. Communications closets must be cooled in accordance with the requirements of EIA/TIA Standard 569. Closets which house critical communications components shall be provided with dedicated air-conditioning systems that shall be connected to the emergency power distribution system.

Elevator Machine Rooms. A dedicated heating and/or cooling system must be provided to maintain room mechanical conditions required by equipment specifications, and in accordance with Table 5-1 of this chapter.

In the event the building is equipped throughout with automatic sprinklers, hoistway venting is not required.

Emergency Generator Rooms. The environmental systems shall meet the requirements of NFPA Standard 110: *Emergency and Standby Power Systems* and meet the combustion air requirements of the equipment. Rooms must be ventilated sufficiently to remove heat gain from equipment operation. The air supply and exhaust shall be located so air does not short circuit. Generator exhaust should be carried up to roof level (GSA preference) in a flue or exhausted by way of compliance with the generator manufacturer's installation guidelines. Horizontal exhaust through the building wall should be avoided.

UPS Battery Rooms. Battery rooms must be equipped with eye wash, emergency showers and floor drains. The battery room must be ventilated/exhausted directly to the outdoors at a rate calculated to be in compliance with code requirements and manufacturer's recommendations, and the exhaust system must be connected to the emergency power distribution system. Fans shall be spark-resistant, explosion proof, with motor outside the air stream, ductwork to be negative pressure system of corrosion-resistant material, with exhaust directly to outdoors in a dedicated system. Acoustical enclosures shall be provided to maintain a maximum NC level of 35. Coordinate with electrical design specifications to include HVAC support equipment in UPS extended servicing agreements.

Loading Docks. The entrances and exits at loading docks and service entrances shall be provided with a positive means to reduce infiltration and outside debris. Loading docks must be maintained at negative pressure relative to the rest of the building.

24-Hour Spaces. All areas designated as requiring 24-hour operations shall be provided with a dedicated and independent HVAC system. All spaces handling BAS computer processing of Fire Alarm Monitor and Control Systems, Security Monitor and Control Systems and/or energy monitoring and control systems shall be provided with dedicated HVAC systems to maintain temperature, humidity and ventilation requirements at all times. Twenty-four hour systems shall have dedicated chiller(s), cooling tower(s) boiler(s), and associated pumping systems. However, central system(s) can be used to provide chilled water and hot water during the normal operating hours, or as a backup for the 24-hour system(s). Twenty-four hour systems with a capacity of up to 50 tons should be configured with an air-cooled chiller. In the event the building's 24-hour operation load, including the dedicated perimeter ventilation system, exceed 50 tons, the cooling systems may be combined with a central system of which a dedicated central chilled water supply loop shall be provided along with 24-hour chiller.

Artwork. In general, it is important to keep within an RH range of 30 to 70%. In a hot and dry geographic region it makes sense to maintain a range that errs on the low side (20 to 40%), while in semitropical climates a range of 55 to 75% may be practical.

Please consult Chapter 4.1, Installation Standards, of the *Fine Arts Program Desk Guide* for additional information.

Fire Protection and Smoke Control. Refer to Chapter 7: *Fire Protection Engineering,* for fire protection and smoke control requirements.

5.9 HVAC Systems and Components

HVAC Systems

Perimeter Outside Air Ventilation Systems. Perimeter ventilation units shall be self-contained DX package units or air-handling units with fan section having variable speed drive, chilled water cooling coil, hot water heating coil, enthalpy heat recovery wheel, or desiccant wheel and supply air filtration. The perimeter ventilation units shall provide 100-percent outside air. Reheat shall be hot gas bypass, a heat pipe or a run around coil. Chilled water shall be generated by an air-cooled chiller or a 24-hour chiller. If a desiccant wheel is used for controlling the specific humidity discharge at the wheel, condenser reheat shall be used for regeneration of the desiccant, along with minimum electric backup. Supply air dew point leaving the unit shall be maintained at 10°C (50°F) and the supply air dry bulb temperature leaving the air-handling unit shall be a minimum of 21.1°C (70° F) and not greater than 25.6°C (78° F) during occupied hours. During occupied hours, this unit shall operate to deliver conditioned ventilation air and maintain positive pressure in the perimeter zone with respect to outside air pressure. During unoccupied hours, the unit shall run at 40 percent of its capacity to provide conditioned air at 10°C (50° F) dew point and at least 21.1°C (70°F) to help maintain positive pressure in the perimeter zone with respect to outside air. In both the occupied and unoccupied modes the system shall operate to adjust the airflow as required to maintain a differential positive pressure in the perimeter zone relative to the prevailing pressure outside the building. When the outside air dew point drops below 2.8°C (37°F), the unit shall have the capacity to maintain neutral pressure with respect to the outside by exhausting relief air from the return duct system. The ventilation unit shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS direct digital control (DDC) Building Automation System. It shall also be equipped with dampers to set the design airflow through the unit, and also an analog or digital display which measures and displays the amount of air flowing through the unit continuously.

Interior Outside Air Ventilation Systems. Interior ventilation units shall be self-contained DX packaged units or air-handling units with chilled water-cooling coil, hot water heating coil, and supply air filtration. Interior ventilation units shall incorporate enthalpy heat recovery wheel or desiccant wheel, heating coil, and a cooling coil. Heat recovery shall include use of building relief and exhaust air. Utilize condenser waste heat for desiccant regeneration. The supply air from the ventilation units shall be ducted to the return plenum section of the air-handling unit(s) serving the interior zones. Supply air dew point leaving the unit shall be maintained at 10°C (50°F) and the supply air dry bulb temperature shall be a minimum of 21.1°C (70° F) and not greater than 25.6°C (78° F). During occupied hours, this unit shall operate to provide conditioned ventilation air. The unit shall be inoperative during unoccupied hours. The unit shall have air-monitoring devices to indicate that the supply air is always 10 percent greater than the exhaust/relief air. The dedicated ventilation unit shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS Direct Digital Control (DDC) Building Automation System. It shall also be equipped with dampers to set the design airflow through the unit, and also an analog or digital display which measures and displays the amount of air flowing through the unit continuously.

Fan Coil System. For perimeter spaces, provide four-pipe fan coil units with cooling coil, heating coil, 35 percent efficiency filters, internal condensate drain, and overflow drain. Unit shall have self-contained microprocessor controls and shall be capable of connecting to and interoperating with a BACnet or LONWORKS Direct Digital Control (DDC) Building Automation System. Fan coil units shall be capable of operating with unit mounted or remote mounted temperature sensor.

Fin Tube Heating Systems. When fin-tube radiation is used, reheat should not be featured with perimeter air distribution systems. Fin-tube radiation shall have individual zone thermostatic control capable of connecting to a self-contained microprocessor that can interface with a BACnet or LONWORKS Direct Digital Control (DCC) Building Automation System.

Variable Volume System with Shutoff Boxes. Variable Air Volume (VAV) systems with full shutoff VAV boxes shall be used for perimeter zone applications only. VAV shutoff boxes shall be used only with the perimeter air distribution systems in order to eliminate the need for reheat. The air-handling unit and associated VAV boxes shall have self-contained microprocessor controls capable of connecting to and interoperating with a Direct Digital Control (DDC) Building Automation System.

Variable Volume System with Fan-Powered Boxes. Variable air volume (VAV) systems with fan-powered VAV boxes may be used for both perimeter and interior zone applications. The air-handling unit and associated VAV boxes shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS Direct Digital Control (DDC) Building Automated System. Fan powered boxes shall be equipped with a ducted return, featuring a filter/filter rack assembly and covered on all external exposed sides with two-inches of insulation. The return plenum box shall be a minimum of 61 mm (24 inches) in length and shall be double wall with insulation in-between or contain at least one elbow where space allows. Fan-powered boxes may have hot water heating coils used for maintaining temperature conditions in the space under partial load conditions. Fan powered boxes located on the perimeter zones and on the top floor of the building shall contain hot water coils for heating.

Underfloor Air Distribution System. Underfloor air distribution systems shall incorporate variable air volume (VAV) units designed to distribute the supply air from under the floor using variable volume boxes or variable volume dampers running out from underfloor, ducted, main trunk lines. Air shall be distributed into the space through floor-mounted supply registers that shall be factory fabricated with manual volume control dampers. Supply air temperature for underfloor systems shall be between 10°C (50°F) dew point and 18°C (64°F) dry bulb. For perimeter underfloor systems, provide fan coil units or fin tube radiators located beneath the floor with supply air grilles or registers mounted in the floor. The air-handling unit, VAV boxes, and variable volume dampers shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS direct digital control (DDC) Building Automation System. The maximum zone size of an underfloor air distribution system shall not exceed 2,360 l/s (5,000 CFM).

Underfloor Air Displacement System. Underfloor air displacement systems shall incorporate variable air volume (VAV) units designed to distribute the supply air from under the floor using variable volume boxes or variable volume dampers running out from underfloor, ducted, main trunk lines. The VAV boxes or control dampers shall be hard ducted or connected directly to the main trunk lines. Air shall be distributed into the occupied space through floor-mounted, low-turbulence, displacement flow, swirl diffusers and shall contain a dust collection basket situated below the floor. Supply air temperature for underfloor systems shall be 10°C (50°F) dew point and 18°C (64°F) Dry Bulb. For perimeter underfloor systems, provide fan coil units or fin tube radiators located beneath the floor with supply air grilles or registers mounted in the floor. The air-handling unit, VAV boxes, and variable volume dampers shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS Direct Digital Control (DDC) Building Automation System. The maximum capacity of an underfloor air distribution system shall not exceed 2,360 l/s (5,000 cfm).

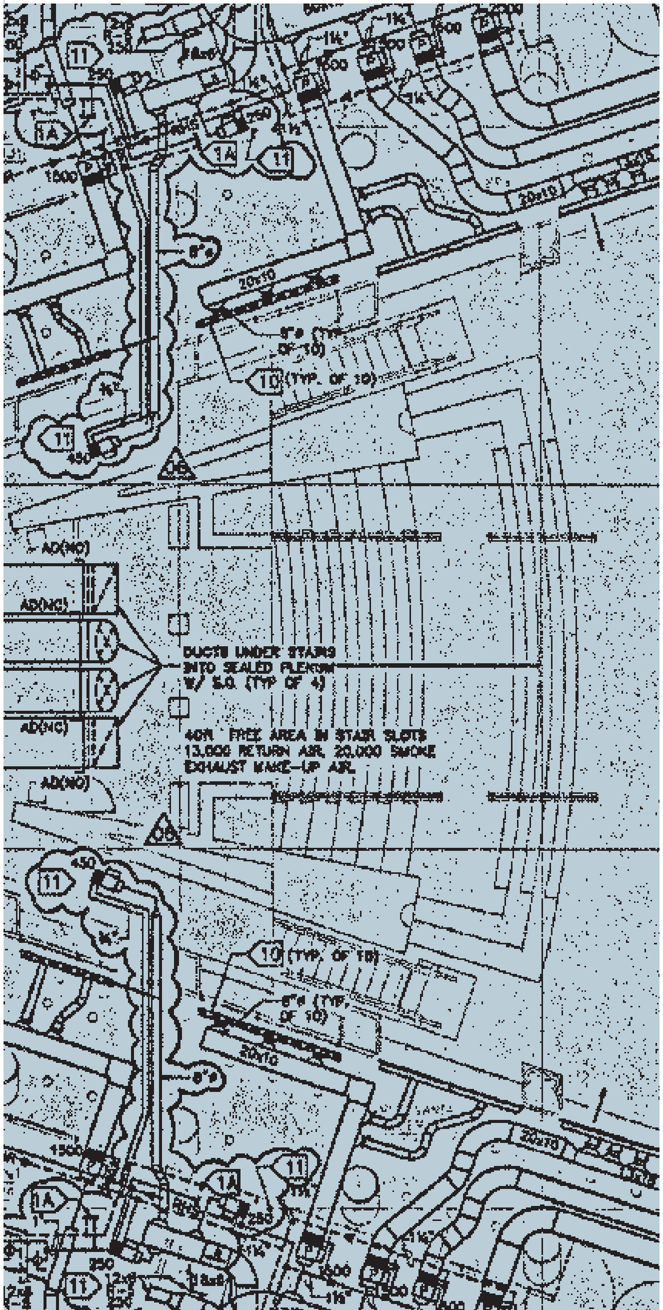
Heat Pump Systems. Console perimeter heat pump system(s) may be considered for the perimeter zone. For the interior zone either a packaged heat pump variable volume system or a central station air handling unit with cooling-heating coil with VAV boxes shall be considered. Condenser water loop temperatures shall be maintained between 15°C (60°F) and 27°C (80°F) year round, either by injecting heat from a gas fired, modular boiler if the temperature drops below 15°C (60°F) or by rejecting the heat through a cooling tower if the temperature of the loop rises above 35°C (95°F) dry bulb. Outside air shall be ducted to the return plenum section of the heat pump unit. Heat pumps shall be provided with filter/filter rack assemblies upstream of the return plenum section of the air-handling unit.

HVAC System Components

Air-Handling Units (AHU's). Air-handling units shall be sized to not exceed 11,800 l/s (25,000 cfm). Smaller units are encouraged to facilitate flexible zone control, particularly for spaces that involve off-hour or high-load operating conditions. To the extent possible, "plug-n-play" AHU configurations should be considered, facilitating easy future adaptations to space-load changes. Psychrometric analyses (complete with chart diagrams) shall be prepared for each air-handling unit application, characterizing full and part load operating conditions. Air-handling unit/coil designs shall assure that conditioned space temperatures and humidity levels are within an acceptable range, per programmed requirements, and ASHRAE Standards 55 and 62.

Depending on sensible heat ratio characteristics, effective moisture control may require cooling coil air discharge dew point temperatures as low as 10°C (50°F). As required, provide face-by-pass or heat recovery features to re-heat cooling coil discharge temperatures for acceptable space entry. Provide a direct form of re-heat and/or humidification only if space conditions require tight environmental control, or if recurring day-long periods of unacceptable humidity levels would otherwise result.

Supply, Return and Relief Air Fans: Centrifugal double-width double-inlet forward curved and airfoil fans are preferable for VAV systems. All fans shall bear the AMCA seal and performance shall be based on tests made in accordance with AMCA Standard 210. Fans should be selected on the basis of required horsepower as well as sound power level ratings at full load and at part load conditions. Fan motors shall be sized so they do not run at overload anywhere on their operating curve. Fan operating characteristics must be checked for the entire



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range of flow conditions, particularly for forward curved fans. Fan drives shall be selected for a 1.5 service factor and fan shafts should be selected to operate below the first critical speed. Thrust arresters should be designed for horizontal discharge fans operating at high static pressure.

Coils: Individual finned tube coils should generally be between six and eight rows with at least 2.1 mm between fins (12 fins per inch) to ensure that the coils can be effectively and efficiently cleaned. Dehumidifying coils shall be selected for no more than negligible water droplet carryover beyond the drain pan at design conditions. All hot water heating and chilled water cooling coils shall be copper tube and copper finned materials. Equipment and other obstructions in the air stream shall be located sufficiently downstream of the coil so that it will not come in contact with the water droplet carryover. Cooling coils shall be selected at or below 2.5 m/s face velocity (500 fpm) to minimize moisture carryover. Heating coils shall be selected at or below 3.8 m/s face velocity (750 fpm).

Drains and Drain Pans: Drain pans shall be made of stainless steel, insulated and adequately sloped and trapped to assure drainage. Drains in draw-through configurations shall have traps with a depth and height differential between inlet and outlet equal to the design static pressure plus 2.54 mm (1 inch) minimum.

Filter Sections: Air filtration shall be provided in every air-handling system. Air-handling units shall have a disposable pre-filter and a final filter. The filter media shall be rated in accordance with *ASHRAE Standard 52.* Pre-filters shall be 30 percent to 35 percent efficient. Final filters shall be filters with 85 percent efficiency capable of filtering down to 3.0 microns per *ASHRAE 52.* Filter racks shall be designed to minimize the bypass of air around the filter media with a maximum bypass leakage of 0.5 percent.

Filters shall be sized at 2.5 m/s (500 FPM) maximum face velocity. Filter media shall be fabricated so that fibrous shedding does not exceed levels prescribed by *ASHRAE 52*. The filter housing and all air-handling components downstream shall not be internally lined with fibrous insulation. Double-wall construction or an externally insulated sheet metal housing is acceptable. The filter change-out pressure drop, not the initial clean filter rating, must be used in determining fan pressure requirements. Differential pressure gauges and sensors shall be placed across each filter bank to allow quick and accurate assessment of filter dust loading as reflected by air-pressure loss through the filter and sensors shall be connected to building automation system.

UVC Emitters/Lamps: Ultraviolet light (C band) emitters/lamps shall be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer. Applied fixtures/lamps must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

Access Doors: Access Doors shall be provided at air handling units downstream of each coil, upstream of each filter section and adjacent to each drain pan and fan section. Access doors shall be of sufficient size to allow personnel to enter the unit to inspect and service all portions of the equipment components.

Plenum Boxes: Air-handling units shall be provided with plenum boxes where relief air is discharged from the air-handling unit. Plenum boxes may also be used on the return side of the unit in lieu of a mixing box. Air-flow control dampers shall be mounted on the ductwork connecting to the plenum box.

Mixing Boxes: Air-handling units shall be provided with mixing boxes where relief air is discharged from the air-handling unit. Mixing boxes may also be used on the return side of the unit in lieu of a plenum box. Air flow control dampers shall be mounted within the mixing box or on the ductwork connecting to the mixing box.

Terminals. *VAV terminals* shall be certified under the ARI Standard 880 Certification Program and shall carry the ARI Seal. If fan-powered, the terminals shall be designed, built, and tested as a single unit including motor and fan assembly, primary air damper assembly and any accessories.

VAV terminals shall be pressure-independent type units.

Units shall have BACnet or LONWORKS self-contained controls.

Fan-powered terminals: Fan-powered terminals shall utilize speed control to allow for continuous fan speed adjustment from maximum to minimum, as a means of setting the fan airflow. The speed control shall incorporate a minimum voltage stop to ensure the motor cannot operate in the stall mode.

All terminals shall be provided with factory-mounted direct digital controls compatible and suitable for operation with the BAS.

Air Delivery Devices. Terminal ceiling diffusers or booted-plenum slots should be specifically designed for VAV air distribution. Booted plenum slots should not exceed 1.2 meters (4 feet) in length unless more than one source of supply is provided. "Dumping" action at reduced air volume and sound power levels at maximum m3/s (cfm) delivery should be minimized. For VAV systems, the diffuser spacing selection should not be based on the maximum or design air volumes but rather on the air volume range where the system is expected to operate most of the time. The designer should consider the expected variation in range in the outlet air volume to ensure the air diffusion performance index (ADPI) values remain above a specified minimum. This is achieved by low temperature variation, good air mixing, and no objectionable drafts in the occupied space, typically 150 mm (6 inch) to 1830 mm (6 feet) above the floor. Adequate ventilation requires that the selected diffusers effectively mix the total air in the room with the supplied conditioned air, which is assumed to contain adequate ventilation air.

Motors. All motors shall have premium efficiency as per *ASHRAE 90.1*. 1/2 HP and larger shall be polyphase. Motors smaller than 1/2 HP shall be single phase. For motors operated with variable speed drives, provide insulation cooling characteristics as per NEC and NFPA.

Boilers. Boilers for hydronic hot water heating applications shall be low pressure, with a working pressure and maximum temperature limitation as previously stated, and shall be installed in a dedicated mechanical room with all provisions made for breeching, flue stack and combustion air. For northern climates, a minimum of three equally sized units shall be provided. Each of the three units shall have equal capacities such that the combined capacity of the three boilers shall satisfy 120 percent of the total peak load of heating and humidification requirements. For southern climates, a minimum of two equally sized units at 67 percent of the peak capacity (each) shall be provided. The units shall be packaged, with all components and controls factory pre-assembled. Controls and relief valves to limit pressure and temperature must be specified separately. Burner control shall be return water temperature actuated and control sequences, such as modulating burner control and outside air reset, shall be utilized to maximum efficiency and performance. Multiple closet type condensing boilers shall be utilized, if possible. Boilers shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS Direct Digital Control (DDC) Building Automated System. Boilers shall have a minimum efficiency of 80 percent as per *ASHRAE 90.1.*

Individual boilers with ratings higher than 29 MW (100 million Btu/hour) or boiler plants with ratings higher than 75 MW (250 million Btu/hour) are subject to review by the Environmental Protection Agency.

Boilers shall be piped to a common heating water header with provisions to sequence boilers on-line to match the load requirements. All units shall have adequate valving to provide isolation of off-line units without interruption of service. All required auxiliaries for the boiler systems shall be provided with expansion tanks, heat exchangers, water treatment and air separators, as required.

Gas Trains: Boiler gas trains shall be in accordance with International Risk Insurance (IRI) standards.

Automatic Valve Actuators: Gas valve actuators shall not contain NaK (sodium-potassium) elements since these pose a danger to maintenance personnel.

Venting: Products of combustion from fuel-fired appliances and equipment shall be delivered outside of the building through the use of breeching, vent, stack and chimney systems. Breeching connecting fuel-fired equipment to vents, stacks and chimneys shall generally be horizontal and shall comply with NFPA 54. Vents, stacks and chimneys shall generally be vertical and shall comply with NFPA 54 and 211. Breeching, vent, stack, and chimney systems may operate under negative, neutral, or positive pressure and shall be designed relative to the flue-gas temperature and dew point, length and configuration of the system, and the value of the insulation techniques applied to the vent. Venting materials may be factory fabricated and assembled in the field and may be double or single wall systems depending on the distance from adjacent combustible or noncombustible materials. Material types, ratings and distances to adjacent building materials shall comply with NFPA 54 and 211.

Heat Exchangers. Steam-to-water heat exchangers shall be used in situations where district steam is supplied and a hot water space heating and domestic hot water heating system have been selected. Double-wall heat exchangers shall be used in domestic hot water heating applications. Plate heat exchangers shall be used for waterside economizer applications.

Chillers. Chillers shall be specified in accordance with the latest Air-conditioning and Refrigeration Institute (ARI) ratings procedures and latest edition of the *ASHRAE Standard 90.1*. As a part of the life cycle cost analysis, the use of high-efficiency chillers with COP and IPLV ratings that exceed 6.4 (0.55 kW/ton) should be analyzed. Likewise, the feasibility of gas-engine driven chillers, ice storage chillers, and absorption chillers should be considered for demand shedding and thermal balancing of the total system.

BACnet or LONWORKS Microprocessor-based controls shall be used. The control panel shall have self-diagnostic capability, integral safety control and set point display, such as run time, operating parameters, electrical low voltage and loss of phase protection, current and demand limiting, and output/input-COP [input/output (kW/ton)] information.

Chilled water machines: When the peak cooling load is 1760 kw (500 tons) or more, a minimum of three chilled water machines shall be provided. The three units shall have a combined capacity of 120 percent of the total peak cooling load with load split percentages 40-40-40 or 50-50-20. If the peak cooling load is less than 1760 kW (500 tons), a minimum of two equally sized machines at 67 percent of the peak capacity (each) shall be provided. All units shall have adequate valving to provide isolation of the off-line unit without interruption of service. Cooling systems with a capacity less than 50 tons shall use air-cooled chillers.

Chillers shall be piped to a common chilled water header with provisions to sequence chillers on-line to match the load requirements. All required auxiliaries for the chiller systems shall be provided with expansion tanks, heat exchangers, water treatment and air separators, as required. If multiple chillers are used, automatic shutoff valves shall be provided for each chiller.

Chiller condenser bundles shall be equipped with automatic reversing brush-type tube cleaning systems.

Chiller condenser piping shall be equipped with recirculation/bypass control valves to maintain incoming condenser water temperature within chiller manufacturer's minimum.

Part load efficiency must be specified in accordance with ARI Standard 550/590.

The design of refrigeration machines must comply with Clean Air Act amendment Title VI: *Stratospheric Ozone Protection* and Code of Federal Regulations (CFR) 40, Part 82: *Protection of Stratospheric Ozone.*

Chlorofluorocarbon (CFC) refrigerants are not permitted in new chillers. Acceptable non-CFC refrigerants are listed in EPA regulations implementing Section 612 (Significant New Alternatives Policy (SNAP) of the Clean Air Act, Title VI: *Stratospheric Ozone Protection.* (Note: GSA accepts these criteria in documenting certification of LEED ratings.)

Refrigeration machines must be equipped with isolation valves, fittings and service apertures as appropriate for refrigerant recovery during servicing and repair, as required by Section 608 of the Clean Air Act, Title VI. Chillers must also be easily accessible for internal inspections and cleaning.

Ice Storage Equipment. Ice-on-coil systems shall be considered in locations where the demand costs of electricity are greater than $15.00 per kW (demand costs for peak generation, transmission, and delivery costs), including prefabricated tanks with glycol coils and water inside the tank. The tank shall be insulated and its capacity and performance shall be guaranteed by the vendor. Self-contained, fabricated ice storage system shall have self-contained BACnet LONWORKS microprocessor controls for charging and discharging the ice storage system and capable of being connected to a central building automation system. Other types of ice storage systems are not permitted.

Cooling Towers. Multiple cell towers and isolated basins are required to facilitate operations, maintenance and redundancy. The number of cells shall match the number of chillers. Supply piping shall be connected to a manifold to allow for any combination of equipment use. Multiple towers shall have equalization piping between cell basins. Equalization piping shall include isolation valves and automatic shutoff valves between each cell. Cooling towers shall have ladders and platforms for ease of inspections and replacement of components. Variable speed pumps for multiple cooling towers shall not operate below 30 percent of rated capacity.

Induced draft cooling towers with multiple-speed or variable-speed condenser fan controls shall be considered. Induced draft towers shall have a clear distance equal to the height of the tower on the air intake side(s) to keep the air velocity low. Consideration shall be given to piping arrangement and strainer or filter placement such that accumulated solids are readily removed from the system. Clean-outs for sediment removal and flushing from basin and piping shall be provided.

Forced draft towers shall have inlet screens. Forced draft towers shall have directional discharge plenums where required for space or directional considerations. Consideration shall be given to piping arrangement and strainer or filter placement such that accumulated solids are readily removed from the system. Clean-outs for sediment removal and flushing from basin and piping shall be provided. The cooling tower's foundation, structural elements and connections shall be designed for a 44 m/s (100 MPH) wind design load. Cooling tower basins and housing shall be constructed of stainless steel. If the cooling tower is located on the building structure, vibration and sound isolation must be provided. Cooling towers shall be elevated to maintain required net positive suction head on condenser water pumps and to provide a 4-foot minimum clear space beneath the bottom of the lowest structural member, piping or sump, to allow re-roofing beneath the tower.

Special consideration should be given to de-icing cooling tower fills if they are to operate in sub-freezing weather, such as chilled water systems designed with a water-side economizer. A manual shutdown for the fan shall be provided. If cooling towers operate intermittently during sub-freezing weather, provisions shall be made for draining all piping during periods of shutdown. For this purpose indoor drain down basins are preferred to heated wet basins at the cooling tower. Cooling towers with waterside economizers and designed for year-round operation shall be equipped with basin heaters. Condenser water piping located above-grade and down to 3 feet below grade shall have heat tracing. Cooling towers shall be provided with BACnet LONWORKS microprocessor controls, capable of connecting to central building automation systems.

Chilled Water, Hot Water, and Condenser Water Pumps. Pumps shall be of a centrifugal type and shall generally be selected to operate at 1750 RPM. Both partial load and full load must fall on the pump curve. The number of primary chilled water and condenser water pumps shall correspond to the number of chillers, and a separate pump shall be designed for each condenser water circuit. Variable volume pumping systems should be considered for all secondary piping systems with pump horsepower greater than 10 kW (15 HP). The specified pump motors shall not overload throughout the entire range of the pump curve. Each pump system shall have a standby capability for chilled, hot water, and condenser water pumps.

Each boiler cooling tower and chiller group pumps shall be arranged with piping, valves, and controls to allow each chiller-tower group to operate independently of the other chiller and cooling tower groups.

See Chapter 7, "*Fire Protection Engineering*," for fire protection provisions for cooling towers.

5.10 Humidification and Water Treatment

Humidifiers and Direct Evaporative Coolers. Make-up water for direct evaporation humidifiers and direct evaporative coolers, or other water spray systems shall originate directly from a potable source that has equal or better water quality with respect to both chemical and microbial contaminants. Humidifiers shall be designed so that microbiocidal chemicals and water treatment additives are not emitted in ventilation air. All components of humidification equipment shall be stainless steel. Air washer systems are not permitted for cooling.

Humidification shall be limited to building areas requiring special conditions. Courtrooms with wall coverings of wood shall be provided with humidification. General office space shall not be humidified unless severe winter conditions are likely to cause indoor relative humidity to fall below 30 percent. Where humidification is necessary, atomized hot water, clean steam or ultrasound may be used and shall be generated by electronic or steam-to-steam generators. To avoid the potential for oversaturation and condensation at low load, the total humidification load shall be divided between multiple, independently-modulated units. Single-unit humidifiers are not acceptable. When steam is required during summer seasons for humidification or sterilization, a separate clean steam generator shall be provided and sized for the seasonal load. Humidifiers shall be centered on the air stream to prevent stratification of the moist air. All associated equipment and piping shall be stainless steel. Humidification system shall have microprocessor controls and the capability to connect to building automation systems.

Water Treatment. The water treatment for all hydronic systems, including humidification systems, shall be designed by a qualified specialist. The design system shall address the three aspects of water treatment: biological growth, dissolved solids and scaling, and corrosion protection. The performance of the water treatment systems shall produce, as a minimum, the following characteristics; hardness: 0.00; iron content: 0.00; dissolved solids: 1,500 to 1,750 ppm; silica: 610 ppm or less; and a PH of 10.5 or above. The system shall operate with an injection pump transferring chemicals from solution tank(s) as required to maintain the conditions described. The chemical feed system shall have self-contained microprocessor controls capable of connecting to and interoperating with a Direct Digital Control (DDC) Building Automation System. The methods used to treat the systems' make-up water shall have prior success in existing facilities on the same municipal water supply and follow the guidelines outlined in *ASHRAE Applications Handbook.*

5.11 Heating Systems

College Park, MD

Steam Heating

District steam heating, if available, shall be used if determined to be economical and reliable through a life cycle cost analysis. If steam is furnished to the building, such as under a district heating plan, it should be converted to hot water with a heat exchanger in the mechanical room near the entrance into the building. If steam heating is used, the designer shall investigate the use of district steam condensate for pre-heating of domestic hot water. Steam heating is not permitted inside the building other than conversion of steam-to-hot water in the mechanical room.

Also, the use of steam for HVAC applications shall be limited to the conversion of steam heat to hot water heat and for use in providing humidification. Steam shall not be used as a heating medium for distribution throughout a building to terminal units, air handling units, perimeter heating units, coils, or any other form of heat transfer where steam is converted to a source of heat for use in space comfort control or environmental temperature control.

Steam delivered from any source other than a clean steam generation system shall be prohibited from use in providing humidification. Steam delivered from a central plant, a district steam system, steam boilers, or any equipment where chemicals are delivered into the medium resulting in the final product of steam shall not be used for the purpose of providing humidification to the HVAC system or occupied spaces.

Hot Water Heating Systems

GSA prefers low-temperature hot-water heating systems; 205 kPa (30 psi) working pressure and maximum temperature limitation of 93.3°C (200°F). The use of electric resistance and/or electric boilers as the primary heating source for the building is prohibited. Design and layout of hydronic heating systems shall follow the principles outlined in the latest edition of the *ASHRAE Systems and Equipment Handbook.*

Water Treatment. See section *"Humidification and Water Treatment"* of this chapter for water treatment.

Temperature and Pressure Drop. Supply temperatures and the corresponding temperature drops for space heating hot water systems must be set to best suit the equipment being served. Total system temperature drop should not exceed 22°C (72°F). The temperature drop for terminal unit heating coils shall be 11°C (52°F). Design water velocity in piping should not exceed 2.5 meters per second (8 feet per second) or design pressure friction loss in piping systems should not exceed 0.4 kPa per meter (4 feet per 100 feet), whichever is larger, and not less than 1.3 meters per second (4 feet per second).

Freeze Protection. Propylene glycol manufactured specifically for HVAC systems shall be used to protect hot water systems from freezing, where extensive runs of piping are exposed to weather, where heating operations are intermittent or where coils are exposed to large volumes of outside air. Freeze protection circulation pump shall be provided along with polypropylene glycol. Heat tracing systems are not acceptable for systems inside the building. Glycol solutions shall not be used directly in boilers, because of corrosion caused by the chemical breakdown of the glycol. The water make-up line for glycol systems shall be provided with an in-line water meter to monitor and maintain the proper percentage of glycol in the system. Provisions shall be made for drain down, storage and re-injection of the glycol into the system.

Radiant Heat. Radiant heating systems (hot water or gas fired) may be overhead or underfloor type. They should be considered in lieu of convective or all-air heating systems in areas that experience infiltration loads in excess of two air changes per hour at design heating conditions. Radiant heating systems may also be considered for high bay spaces and loading docks.

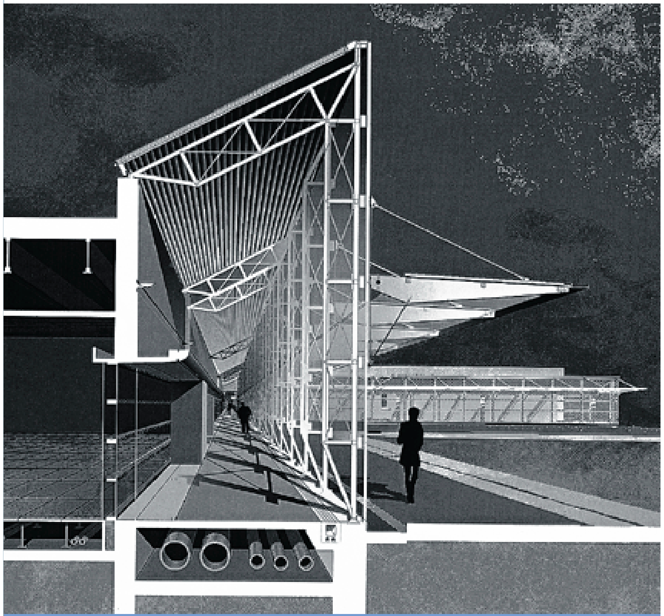
Instantaneous Hot Water. The use of instantaneous hot water generators is prohibited except for incidental use at terminal fixtures.

Natural Gas Piping. Refer to *Plumbing Systems, Natural Gas Systems* section of this chapter.

Fuel Oil Piping. Refer to *Plumbing Systems, Fuel Oil Systems* section of this chapter.

Underground Fuel Oil. Refer to *Plumbing Systems, Fuel Oil Systems* section of this chapter.

5.12 Cooling Systems



U.S. Census Bureau

Chilled Water Systems

Chilled water systems include chillers, chilled water and condenser water pumps, cooling towers, piping and piping specialties.

The chilled water systems shall have a 10°C (50°F) temperature differential in the central system, at the central plant, with a design supply water temperature between 4°C and 7°C (40°F and 45°F). In climates with low relative humidity, an 8°C (46°F) may be used. The chilled water system shall have a 6°C (43°F) temperature differential in the secondary systems, at the terminal points of use, such as coils with a design supply water temperature between 4°C and 7°C (40°F and 45°F).

District chilled water, if available, shall be used for cooling only if determined to be economical and reliable through a life cycle cost analysis.

Mechanical equipment rooms must be designed in accordance with the requirements of *ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.* Chiller leak detection and remote alarming shall be connected to the BAS.

Freeze Protection. Propylene glycol manufactured specifically for HVAC Systems is used for freeze protection, primarily in low temperature chilled water systems (less than 4°C) (less than 40°F). The concentration of antifreeze should be kept to a practical minimum because of its adverse effect on heat exchange efficiency and pump life. The water make-up line for glycol systems shall be provided with an in-line water meter to monitor and maintain the proper percentage of glycol in the system. All coils exposed to outside airflow (at some time) shall be provided with freeze protection thermostats and control cycles. Provisions shall be made for drain down, storage and re-injection of the glycol into the system.

Condenser Water. All water-cooled condensers must be connected to a recirculating heat-rejecting loop. The heat rejection loop system shall be designed for a 6°C (43°F) temperature differential and a minimum of 4°C (40°F) wet bulb approach between the outside air temperature and the temperature of the water leaving the heat rejection equipment. Heat tracing shall be provided for piping exposed to weather and for piping down to 3 feet below grade.

Water Treatment. See section: *Humidification and Water Treatment* of this chapter for water treatment.

Special Cooling Systems

Waterside Economizer Cycle. In certain climate conditions cooling towers are capable of producing condenser water cold enough to cool the chilled water system without chiller operation. This option shall be considered in life cycle cost comparisons of water cooled chillers. Waterside economizer cycles are particularly cost effective in the low humidity climates of the western United States. In the eastern United States, enthalpy airside economizer cycles tend to produce lower operating costs. However, where used, any airside economizer shall be set so that no air with a dew point above 10°C (50°F) is allowed into the building. Waterside economizer systems shall be used only in areas where the outside air temperature will be below 4.4°C (40°F) wet bulb. Waterside economizers shall utilize a plate heat exchanger piped in parallel arrangement with its respective chiller. See *"Air Distribution Systems, Air-Handling Units, and Airside Economizer Cycle"* of this chapter.

Computer Room Air-Conditioning Units. Mainframe computer rooms shall be cooled by self-contained units for loads up to 280 kW (80 tons). These units shall be specifically designed for this purpose and contain compressors, filters, humidifiers and controls. They shall be sized to allow for a minimum of 50 percent redundancy, either two units at 75 percent load or three units at 50 percent. If the nature of the computer room is critical (as determined by consulting the GSA's Office of the Chief Information Officer), three units sized at 50 percent of the design load shall be used. Heat rejection from these self-contained units shall be by air-cooled condensers or recirculating water-cooled condensers connected to a cooling tower or evaporative-cooled condenser. Water-side free cooling shall be utilized when possible.

For cooling loads greater than 280 kW (80 tons), chilled water air-handling systems shall be considered in a life cycle cost analysis. A dedicated chiller(s) is preferred, unless other parts of the building also require 24-hour cooling. The 24-hour cooling needs of a computer room should be identified in the *HVAC, HVAC System Components, Sizing and Selection Standards for Equipment and Systems* section of this chapter. The dedicated chiller plant shall provide some means of redundant backup, either by multiple machines or connection to the facility's larger chilled water plant.

In large computer installations (areas of 500 m^2(5,000 ft^2)) it is recommended to segregate cooling of the sensible load (computer load) and control of the outside air ventilation and space relative humidity by using two separate air-handling systems. In this design, one unit recirculates and cools room air without dehumidification capability. This unit is regulated by a room thermostat. The second unit handles the outside air load, provides the required number of air changes and humidifies/ dehumidifies in response to a humidistat. This scheme avoids the common problem of simultaneously humidifying and dehumidifying the air.

For ventilation, air-handling, and humidification requirements of computer rooms, see sections *Air Distribution Systems, Air-Handling Units, Computer Room Air-Handling* of this chapter. The room temperature conditions shown in Table 5-1 provide a higher available temperature for reduced fan power consumption and easier winter humidification. Verify with users to determine if the air- conditioning system must be connected to emergency power system. These systems should be provided with an alternative power source, connected to emergency generators, if the computer room houses critical components. Consult GSA's Office of the Chief Information Officer to determine which computer rooms meet this requirement.

Desiccant Cooling. For high occupancy applications where moisture removal is required, solid desiccant with silica gel may be used in combination with mechanical cooling. Heat recovery wheels may be used prior to the mechanical cooling process. Desiccant cooling units shall be equipped with airflow-setting devices for both process and reactivation air flows, and shall be equipped with gauges or digital displays to report those air flows continuously. The desiccant cooling system shall have self-contained microprocessor controls capable of connecting to and interoperating with a direct digital control (DDC) Building Automation system. Natural gas or condenser waste heat shall be used as fuel for reactivation of the desiccant. Lithium chloride liquid desiccants are not permitted.

5.13 Heat Recovery Systems

Heat recovery systems shall be utilized in all ventilation units (100 percent outside air units) and where the temperature differentials between supply air and exhaust air is significant. Heat recovery systems shall operate at a minimum of 70 percent efficiency. The heat recovery systems must be capable of connecting to a microprocessor controller that in turn can be connected to a direct digital control (DDC) Building Automation System. Prefilters shall be provided in all heat recovery systems before the heat recovery equipment.

Heat Pipe. For sensible heat recovery a run around type heat pipe shall use refrigerant to absorb heat from the air stream at the air intake and reject the heat back into the air stream at the discharge of the air-handling unit. System shall have solenoid valve control to operate under partial load conditions.

Run-around Coil. A glycol run-around coil could be used with control valves and a pump for part load conditions. The run-around coils shall be used at the exhaust discharge from the building and at the fresh air intake into the building. The run-around coil system shall be capable of connecting to a microprocessor controller that in turn can be connected to a direct digital control (DDC) Building Automation system.

Enthalpy Wheel. A desiccant-impregnated enthalpy wheel with variable speed rotary wheel may be used in the supply and exhaust systems.

Sensible Heat Recovery. For sensible heat recovery, a cross-flow, air-to-air (z-duct) heat exchanger shall recover the heat in the exhaust and supply air streams. Z-ducts shall be constructed entirely of sheet metal. Heat-wheels may also be used for sensible heat recovery. Unit shall have variable speed drive for controlling the temperature leaving the unit.

5.14 Pressurization and Ventilation

Pressurization

Perimeter Zone. A dedicated 100 percent outside air unit shall be used to maintain positive pressure. The ventilation air for the perimeter air-handling unit shall be sized based on maximum occupancy with diversity and shall operate continuously during occupied hours and operate at 40 percent capacity during unoccupied hours. Industrial grade pressure sensors shall be located at several perimeter areas to communicate outside air pressure to maintain differential positive pressure (adjustable). The internal pressure need only be slightly higher than ambient on average to achieve the goal of excluding humid outdoor air from building cavities. In any case, internal pressure shall not be greater than 10 pascals. Maintain supply air discharge at the unit no more than 10°C (50°F) dewpoint when outside air dewpoint is above this temperature. Maintain neutral pressure ($\Delta P=0$) when the outdoor ambient temperature falls below 3°C(37°F) dewpoint and neutral pressure. Differential pressure sensors and dewpoint sensors shall be connected to the building automation system. An alarm shall signal if positive or neutral pressures are not maintained, on average, based on multiple samples taken within a five-minute period. Only industrial grade sensors are permitted.

Interior Zone. A dedicated outside air-handling unit shall be used to maintain positive pressure. The unit shall be sized based on the fresh air requirements for maximum occupancy with diversity. The unit shall have air-monitoring devices and control the exhaust rate during occupied hours to be less than 10 percent of the supply "air to ensure positive pressure in the space. The unit shall shut down during unoccupied hours. Maintain 10°C (50°F) dewpoint when outside air dewpoint is above that of the outside air. Use humidification equipment, if necessary, to maintain 3°C (37°F) dewpoint whenever outside dewpoint is below 3°C (37°F). Also maintain neutral pressure by setting the exhaust air quantity to equal the supply air rate. Air monitoring devices shall be connected to the building automation system to indicate positive and neutral pressure.

Special Ventilation Requirements

Ventilation requirements for all building spaces shall comply with *ASHRAE 62*.

Entrance Vestibules and Lobbies. Sufficient heating and cooling should be provided to offset the base load plus the infiltration load of the space. The entrance vestibule should be positively pressurized relative to atmospheric pressure to minimize infiltration. A separate variable air volume (VAV) system shall serve entrance vestibules and lobby spaces. The VAV system shall operate to vary the flow of air for the space through a differential pressure control system designed to maintain positive pressure relative to the outdoors and neutral or negative pressure relative to adjacent spaces. Also provide air monitoring devices in the unit. The air-handling unit and the variable volume dampers at the VAV boxes shall have self-contained microprocessor controls capable of connecting to and interoperating with a BACnet or LONWORKS direct digital control (DDC) Building Automation System.

Atriums. A dedicated air-handling system shall be provided to control heat gain/loss in the occupiable areas of the atrium. The atrium area should maintain negative pressure relative to adjacent interior and perimeter spaces or zones and positive or neutral pressure relative to adjacent vestibules and lobbies, and positive pressure relative to the outdoors. The design of the HVAC system must be fully coordinated with the smoke control system.

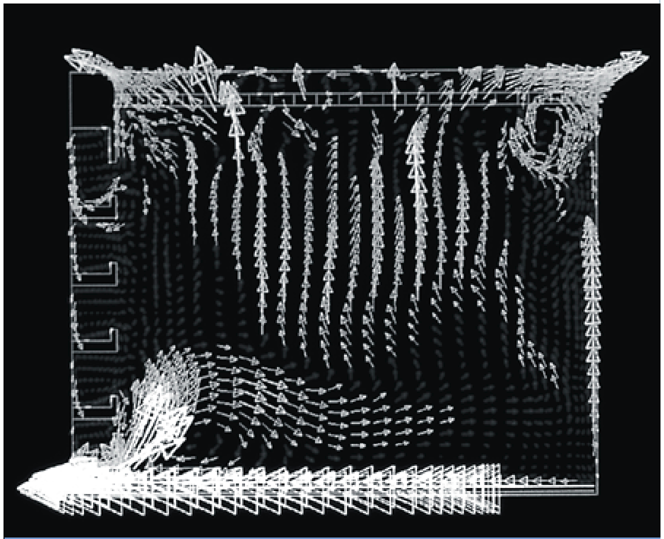
Toilets. Toilet areas must have segregated exhausts and should be negative in pressure relative to surrounding spaces.

Janitor/Housekeeping Closets. Janitor/housekeeping closets must have segregated exhausts and should be negative in pressure to surrounding spaces.

Food Service Areas. Kitchen areas shall be negative in pressure relative to adjacent dining rooms, serving areas and corridors. Tempered make-up air shall be introduced at the kitchen hood and/or the area adjacent to the kitchen hood for at least 80 percent of exhaust air. Duct air velocity in the grease hood exhaust shall be no less than 7.5 to 9 m/s (1,500 to 1,800 FPM) to hold particulate in suspension. Dishwashing areas must be under negative pressure relative to the kitchen, and dishwashers shall be provided with their own exhaust hoods and duct systems, constructed of corrosion-resistant material.

High Occupancy Areas. High occupancy areas, which also have largely variable occupancies, such as conference rooms, lecture theatres, etc., and are served by dedicated ventilation and air-handling systems, shall incorporate a CO_2 demand controlled ventilation (DCV) system to minimize energy consumption, while maintaining appropriate levels of ventilation and pressure relationships between spaces and the outdoors. The DCV system devices shall be located for ease of maintenance and shall provide appropriate operation of the ventilation system it is controlling. Enthalpy heat recovery system shall be utilized if economically feasible.

5.15 Air Distribution Systems



Air Flow Diagram, Atrium, Phoenix Courthouse

Variable Air Volume (VAV) Systems

The VAV supply fan shall be designed for the largest block load, not the sum of the individual peaks. The air distribution system up to the VAV boxes shall be medium pressure and shall be designed by using the static regain method. Downstream of the VAV boxes the system shall be low and medium pressure construction and shall be designed using the equal friction method. Sound lining is not permitted. Double wall ductwork with insulation in-between is permitted in lieu of sound lining. All VAV boxes shall be accessible for maintenance. Ducted return shall be utilized at all locations. VAV fan-powered box supply and return ducts shall have double wall ductwork with insulation in-between for a minimum distance of 5 feet.

Underfloor Air Distribution Systems. Provide plenum zones both for perimeter and interior in order to control the underfloor variable volume dampers or boxes with separate plenum barriers between perimeter and interior zones. The underfloor plenum shall be air tight and compartmentalized with baffles. Provisions shall be provided for cleaning the plenum space. When underfloor supply air distribution is used, the ceiling plenum shall be used for the distribution of the ducted return air. The perimeter and interior underfloor zones shall be clearly separated in order to maintain proper pressurization, temperature and humidity control. Zoning of the underfloor air distribution systems shall be in accordance with descriptions presented elsewhere in this chapter. Perimeter wall below the raised flooring system shall be provided with R-30 insulation and vapor barrier below the raised floor. All VAV boxes that are part of an underfloor air distribution system for both perimeter and interior systems shall be located below the raised floor. The floor area used for an underfloor system shall have the slab provided with a minimum of R-10 insulation and vapor barrier from below. This shall incorporate the entire slab area used for the underfloor system.

Volume Control. Particular attention shall be given to the volume control. VAV systems depend on air volume modulation to maintain the required ventilation rates and temperature set points. Terminal air volume control devices are critical to the successful operation of the system and shall be provided. Zone loads must be calculated accurately to avoid excessive throttling of air flow due to oversized fans and terminal units. Diffusers shall be high entrainment type (3:1 minimum) to maximize air velocity at low flow rates. If ventilation air is delivered through the VAV box, the minimum volume setting of the VAV box should equal the larger of the following:

1. 30 percent of the peak supply volume;
2. 0.002 m3/s per m2 (0.4 cfm/sf) of conditioned zone area; or
3. Minimum m3/s (cfm)to satisfy *ASHRAE Standard 62* ventilation requirements. VAV terminal units must never be shut down to zero when the system is operating. Outside air requirements shall be maintained in accordance with the Multiple Spaces Method, Equation 6-1 of *ASHRAE Standard 62* at all supply air flow conditions.

Airside Economizer Cycle. An air-side enthalpy economizer cycle reduces cooling costs when outdoor air enthalpy is below a preset high temperature limit, usually 15 to 21°C (60°F to 70°F), depending on the humidity of the outside air. Airside economizers shall only be used when they can deliver air conditions leaving the air-handling unit of a maximum of 10°C (50°F) dewpoint and a maximum of 70 percent relative humidity. Enthalpy economizers shall operate only when return air enthalpy is greater than the outside air enthalpy.

All air distributions systems with a capacity greater than 1,416 LPS (3,000 CFM) shall have an air-side economizer in accordance with *ASHRAE 90.1*, unless the design of the air handling systems preclude the use of an airside economizer.

Ductwork. Ductwork shall be designed in accordance with *ASHRAE: Handbook of Fundamentals, Duct Design Chapter*, and constructed in accordance with the *ASHRAE: HVAC Systems and Equipment Handbook, Duct Construction Chapter*, and the *SMACNA Design Manuals.* All ductwork joints and all connections to air handling and air distribution devices shall be sealed with mastic—including all supply and return ducts, any ceiling plenums used as ducts and all exhaust ducts. Energy consumption, security and sound attenuation shall be major considerations in the routing, sizing and material selection for the air distribution ductwork.

Supply, Return and Exhaust Ductwork

Ductwork Pressure. Table 5-3 provides pressure classification and maximum air velocities for all ductwork. Ductwork construction shall be tested for leakage prior to installation. Each section tested must have a minimum of a 20 ft. length straight-run, a minimum of two elbows and a connection to the terminal. The stated static pressures represent the pressure exerted on the duct system and not the total static pressure developed by the supply fan. The actual design air velocity should consider the recommended duct velocities in Table 5-4 when noise generation is a controlling factor. Primary air ductwork (fan connections, risers, main distribution ducts) shall be medium pressure classification as a minimum. Secondary air ductwork (runouts/branches from main to terminal boxes and distribution devices) shall be low pressure classification as a minimum.

Supply, return and exhaust air ducts shall be designed and constructed to allow no more than 3 percent leakage of total airflow in systems up to 750 Pa (3 inches WG). In systems from 751 Pa (3.1 inches WG) through 2500 Pa (10.0 inches WG) ducts shall be designed and constructed to limit leakage to 0.5 percent of the total air flow.

Pressure loss in ductwork shall be designed to comply with the criteria stated above. This can be accomplished by using smooth transitions and elbows with a radius of at least 1.5 times the radius of the duct. Where mitered elbows have to be used, double foil sound attenuating turning vanes shall be provided. Mitered elbows are not permitted where duct velocity exceeds 10m/s (2000 FPM).

Sizing of Ductwork. Supply and return ductwork shall be sized using the equal friction method except for ductwork upstream of VAV boxes. Duct systems designed using the

Table 5-3
Ductwork Classification

Static Pressure		Air Velocity		Duct Class
250 Pa	(1.0 in W.G.)	< 10 m/s DN	< (2000 FPM DN)	Low Pressure
500 Pa	(2.0 in W.G)	< 10 m/s DN	< (2000 FPM DN)	Low Pressure
750 Pa	(3.0 in W.G.)	< 12.5 m/s DN	< (2500 FPM DN)	Medium Pressure
1000 Pa	(+4.0 in W.G.)	< 10 m/s DN	> (2000 FPM UP)	Medium Pressure
1500 Pa	(+6.0 in W.G.)	< 10 m/s DN	> (2000 FPM UP)	Medium Pressure
2500 Pa	(+10.0 in W.G.)	< 10 m/s DN	> (2000 FPM UP)	High Pressure

Table 5-4
Recommended Duct Velocities

Application	Controlling Factor Noise Generation (Main Duct Velocities) m/s	(fpm)
Private Offices Conference Rooms Libraries	6	(1,200)
Theaters Auditoriums	4	(800)
General Offices	7.5	(1,500)
Cafeterias	9	(1,800)

equal friction method place enough static pressure capacity in the supply and return fans to compensate for improper field installation and changes made to the system layout in the future. In buildings with large areas of open plan space, the main duct size shall be increased for revisions in the future. Air flow diversity shall also be a sizing criterion. 80 percent diversity can be taken at the air-handling unit and decreased the farther the ductwork is from the source until air flow diversity is reduced to zero for the final portion of the system.

Ductwork Construction. Ductwork shall be fabricated from galvanized steel, aluminum or stainless steel sheet metal depending on applications. Flex duct may be used for low pressure ductwork downstream of the terminal box in office spaces. The length of the flex duct shall not exceed the distance between the low pressure supply air duct and the diffuser plus 20 percent to permit relocation of diffusers in the future while minimizing replacement or modification of the hard ductwork distribution system. Generally, flex duct runs should not exceed 3 m (10 feet) nor contain more than two bends.

Joint sealing tape for all connections shall be of reinforced fiberglass backed material with field applied mastic. Use of pressure sensitive tape is not permitted.

Kitchen Ventilation Systems. Products of combustion from kitchen cooking equipment and appliances shall be delivered outside of building through the use of kitchen ventilation systems involving exhaust hoods, grease ducts and make-up air systems where required. Commercial kitchen equipment applications shall be served by a Type I hood constructed in compliance with UL 710 and designed in accordance with code having jurisdiction. Grease ducts shall be constructed of black steel not less than 0.055 inch (1.4 mm) (No. 16 gauge) in thickness or stainless steel not less than 0.044 inch (1.1 mm) (No. 18 gauge in thickness).

Make-up air systems serving kitchen exhaust hoods shall incorporate air-side heat exchange to recover energy from the exhaust stream to be used for heating the supply air stream.

Ceiling Plenum Supply. Ceiling plenum supply does not permit adequate control of supply air and shall not be used.

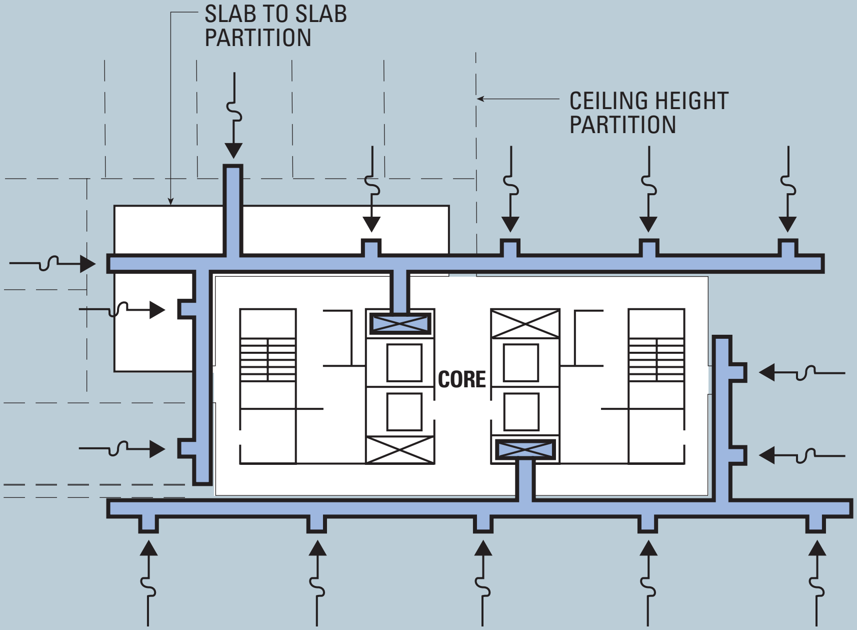
Raised Floor Plenum Supply. In computer rooms, underfloor plenum supplies are appropriate. As a general application in other areas (e.g. open offices), underfloor air distribution/displacement systems are appropriate. Where raised floor plenums are used for supply air distribution, the plenums shall be properly sealed to minimize leakage. R-30 insulation with vapor barrier shall be provided for perimeter of raised floor walls.

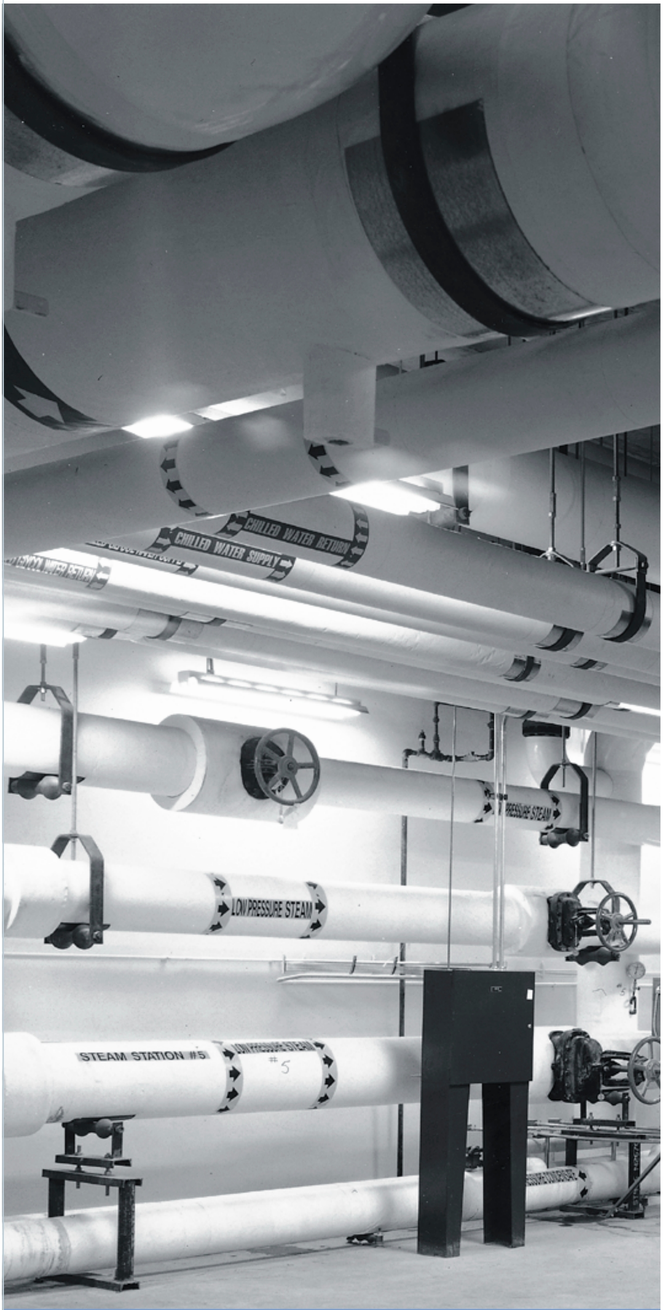
Plenum and Ducted Returns. With a return plenum care must be taken to ensure that the air drawn through the most remote register actually reaches the air-handling unit. The horizontal distance from the farthest point in the plenum to a return duct shall not exceed 15 m (50 feet). No more than 0.8 m3/s (2,000 cfm) should be collected at any one return grille. Figure 5-2 illustrates an example of an open ceiling plenum with return air ductwork. Return air plenums should be avoided. When deemed necessary for economic reasons, plenums shall be sealed air-tight with respect to the exterior wall and roof slab or ceiling deck to avoid creating negative air pressure in exterior wall cavities that would allow intrusion of untreated outdoor air. All central multi-floor-type return air risers must be ducted.

Other less flexible building spaces, such as permanent circulation, public spaces, and support spaces, shall have ducted returns. Where fully ducted return systems are used, consider placing returns low in walls or on columns to complement ceiling supply air.

Return air duct in the ceiling plenum of the floor below the roof shall be insulated. Double wall ductwork with insulation in-between shall be used in lieu of sound lining for a minimum of the last 5 feet before connecting to the air handling unit or a return air duct riser.

Figure 5-2 Ceiling Return Plenum with Minimal Return Ductwork





College Park, Maryland chilled water supply and return

5.16 Pumping Systems

Pump and Piping Systems. The system shall utilize parallel piping systems with a two-pipe main distribution system arranged in a reverse return configuration. Series loop piping for terminal or branch circuits shall be equipped with automatic flow control valves at terminal units (all types of heat transfer units). Reverse return is considered because it provides the best overall control and maintenance of a balanced system as the system is modified. Each terminal unit or coil shall be provided with isolation valves on both the supply and return, and a flow-indicating balance valve on the return line. Isolation valves shall be provided on all major pipe branches, such as at each floor level, building wing or mechanical room.

Each pumping system shall be provided with two pumps, one operating while the other is in standby mode. These pumps shall be configured for automatic lead/ lag operation.

Each boiler shall be provided with a control and piping arrangement, which protects the boiler from thermal shock. A primary-secondary piping arrangement with a modulating mixing control valve and higher primary flow rate will assure that the boiler return water temperature does not drop too low, as commonly occurs with night setback. Hydronic hot water space heating pumps should generally be selected to operate at 1750 RPM. Variable volume pumping systems shall be provided for all secondary piping systems with pump horsepower greater than 10 kW (15 HP).

Refer also to provisions in *Piping Systems* in this chapter.

Pressurized diaphragm expansion tanks shall be used when available in appropriately sized manufactured products. Air separators and vents must be provided on hot water systems to remove accumulated air within the system. Automatic bleed valves shall only be used in accessible spaces in mechanical rooms where they can be observed by maintenance personnel and must be piped directly to open drains. Manual bleed valves shall be used at terminal units and other less accessible high points in the system. Air vents shall be provided at all localized high points of the piping systems and at each heating coil. Likewise, system drains shall be provided at all localized low points of the heating system and at each heating coil.

Hydronic, Closed Loop Systems. Closed piping systems are unaffected by static pressure; therefore, pumping is required only to overcome the dynamic friction losses. Pumps used in closed loop hydronic piping shall be designed to operate to the left of the peak efficiency point on their curves (higher head, less flow). This compensates for variances in pressure drop between calculated and actual values without causing pump overloading. Pumps with steep curves shall not be used, as they tend to limit system flow rates.

Variable Flow Pumping. Variable flows occur when two-way control valves are used to modulate heat transfer. The components of a variable volume pumping system include pumps, distribution piping, control valves and terminal units, and will also include boilers and chillers unless a primary-secondary arrangement is used. All components of the system are subject to variable flow rates. It is important to provide a sufficient pressure differential across every circuit to allow design flow capacity at all times.

Flow may be varied by variable speed pumps or staged multiple pumps. Pumps should operate at no less than 75 percent efficiency on their performance curve. Variable flow pumping must be designed carefully. Package systems should be used, complete with pumps and controls factory-tested prior to shipment.

Chillers and most boilers may experience flow-related heat exchange problems if flow is not maintained above a minimum rate. For this reason, separate, constant flow primary water pumps are recommended for variable volume pumping systems.

Primary/Secondary Pumping. In this application, primary and secondary circuits are separate, with neither having an effect on the pumping head of the other. The primary circuit serves source equipment (chiller or boiler), while the secondary circuit serves the load. Primary/secondary pumping arrangements allow increased system temperature design drops, decreased pumping horsepower and increased system control. The primary loop and pumps are dedicated and sized to serve the flow and temperature differential requirements of the primary source equipment. This permits the secondary pump and loop to be sized and controlled to provide the design flow rate and temperature differential required to satisfy the heating or cooling loads. Primary/secondary systems are recommended for larger buildings (circulation of more than 76 L/s (1,000 gpm)) and campus facilities.

5.17 Piping Systems

All piping systems shall be designed and sized in accordance with *ASHRAE Fundamentals Handbook* and the *ASHRAE HVAC Systems and Equipment Handbook*. Materials acceptable for piping systems are black steel and copper. No PVC or other types of plastic pipe are permitted.

Chilled Water and Condenser Water Piping. In general, HVAC systems shall utilize parallel piping systems with a two-pipe main distribution system arranged in a reverse return configuration. If applied, series loop piping for terminal or branch circuits shall be equipped with automatic flow control valves at terminal units (all types of heat transfer units).

Each terminal unit or coil shall be provided with isolation valves on both the supply and return and a flow indicating balance valve on the return line. Isolation valves shall be provided on all major branches, such as at each floor level, building wing or mechanical room.

For new chilled water HVAC distribution, a pumping and piping arrangement is generally appropriate, with constant volume primary pumping and variable volume secondary pumping. The primary and secondary circuits shall be separate, with neither having an effect on the pumping head of the other. The primary circuit serves the source equipment (chillers), while the secondary circuit serves the load. Refer also to *Pumping Systems* in this chapter for additional requirements.

Cathodic Protection. The need for metal protection for underground piping must be evaluated by a soils resistivity test. This is part of the Geotechnical Report. (See Appendix A.) Cathodic protection or another means of preventing pipe corrosion must be provided if required by the Geotechnical Report.

Piping Material. Table 5-5 cites which commercial standard should be used for piping material.

Isolation of Piping at Equipment. Isolation valves, shutoff valves, by-pass circuits, flanges and unions shall be provided as necessary for piping at equipment to facilitate equipment repair and replacement. Equipment requiring isolation includes boilers, chillers, pumps, coils, terminal units and heat exchangers. Valves shall also be provided for zones off vertical risers.

Provisions for Piping in Earthquake Zones. In Seismic Zones 2, 3 and 4, sleeves for pipes shall be at least 25 mm (1 inch) larger than the pipe, to allow for movement. Flexible couplings shall be provided at the bottom of pipe risers. Spreaders shall be used to separate adjacent pipes, unless the distance is large enough to prevent contact in an earthquake. See Chapter 4: *Structural Engineering,* SMACNA *Seismic Restraint Manual and ASHRAE Application Handbook* for more detailed information.

Piping Supports. Provide channel supports for multiple pipes and heavy duty steel trapezes to support multiple pipes. Hanger and support schedule shall have manufacturer's number, type and location. Comply with MSS SP69 for pipe hanger selections. Spring hangers and supports shall be provided in all the mechanical rooms.

Flexible Pipe Connectors. Flexible pipe connectors shall be fabricated from annular close pitched corrugated and braided stainless steel. All pumps, chillers, and cooling towers shall have flexible connectors.

Piping System and Equipment Identification. All pipes, valves and equipment in mechanical rooms, shafts, ceilings and other spaces *accessible to maintenance personnel* must be identified with color-coded bands and permanent tags indicating the system type and direction of flow for piping systems or type and number for equipment. The identification system shall also tag all valves and other operable fittings. Gas piping and sprinkler lines must be identified as prescribed by NFPA.

Table 5-5
Commercial Standards for Piping Material

Standard Piping Material	Use	Comments
ASTM Schedule 40	Chilled water up to 300 mm (12-in) dia., Condenser water up to 300 mm (12-in) dia.	1035 kPa (150 psi) fittings. Standard weight pipe over 300 mm (12-in) diameter.
	Hot water	Test to 2100 kPa (300 psig)
	Natural gas, fuel oil	Weld and test to 2100 kPa (300 psig)
	Steam (100 kPa (15 psig) to 1035 kPa (150 psi))	
ASTM Schedule 30	Chilled water over 300 mm (12 in) dia Condenser water over 300 mm (12 in) dia.	1035 kPa (150 psi) fittings. Standard weight pipe over 300 mm (12-in) diameter
ASTM Schedule 80	Steam condensate	
Copper Tubing	Chilled water up to 102 mm (4 in) dia, Condenser water up to 102 mm (4 in) dia.	Builder's option. Use type K below ground and type L above.
	Domestic water	Lead-free solder connections.
	Refrigeration	Type ACR.
	Cast Iron Sanitary, waste and vent	
	Storm	

5.18 Thermal Insulation

General

All insulation materials shall comply with the fire and smoke hazard ratings indicated by ASTM-E84, NFPA 255 and UL 723. Accessories such as adhesives, mastics, cements and tapes shall have the same or better fire and smoke hazard ratings.

Insulation shall be provided on all cold surface mechanical systems, such as ductwork and piping, where condensation has the potential of forming and in accordance with *ASHRAE Standard 90.1*. Insulation that is subject to damage or reduction in thermal resistivity if wetted shall be enclosed with a vapor seal (such as a vapor barrier jacket). Insulation shall have zero permeability.

Duct Insulation. Materials used as internal insulation exposed to the air stream in ducts shall be in accordance with UL 181 or ASTM C 1071 erosion tests, and shall not promote or support the growth of fungi or bacteria, in accordance with UL 181 and ASTM G21 and G22. Ductwork with double wall construction having insulation in-between shall only be used for courtroom return air transfer grilles, and only if required for acoustic purposes. All exposed ductwork shall have sealed canvas jacketing. All concealed ductwork shall have foil face jacketing.

The insulation shall comply with fire and smoke hazard ratings indicated by ASTM-E84, NFPA 255 and UL 723. Accessories such as adhesives, mastics, cements, tapes, etc. shall have the same or better component ratings. All supply air ducts must be insulated, in accordance with *ASHRAE Standard 90.1*. Supply air duct insulation shall have a vapor barrier jacket. The insulation shall cover the duct system with a continuous, unbroken vapor seal. Insulation shall have zero permeability.

Return air and exhaust air distribution systems shall be insulated in accordance with *ASHRAE Standard 90.1*. The insulation of return air and exhaust air distribution systems needs to be evaluated for each project and for each system to guard against condensation formation and heat gain/loss on a recirculating or heat recovery system. Generally, return air and exhaust air distribution systems do not require insulation if located in a ceiling plenum or mechanical room used as a return air plenum. All equipment, heat exchangers, converters and pumps shall be insulated as per *ASHRAE Standard 90.1*.

Piping Insulation. All insulation material shall comply with the fire and smoke hazard ratings indicated by ASTM-E84, NFPA 255 and UL 723. Accessories such as adhesives, mastics, cements, tapes, etc. shall have the same or better component ratings. All piping systems must be insulated in accordance with *ASHRAE Standard 90.1*. Piping systems conveying fluids, those having design temperatures less than 18°C (65°F) or greater than 40°C (105°F) shall be insulated. All piping systems with surface temperatures below the average dew point temperature of the indoor ambient air and where condensate drip will cause damage or create a hazard shall be insulated with a vapor barrier to prevent condensation formation regardless to whether piping is concealed or exposed. Chilled water piping systems shall be insulated with non-permeable insulation (of perm rating 0.00) such as cellular glass. All exposed and concealed piping shall have PVC jacketing.

Equipment Insulation. All insulation material shall comply with the fire and smoke hazard ratings indicated by ASTM-E84, NFPA 255 and UL 723. Accessories such as adhesives, mastics, cements, tapes, etc. shall have the same or better component ratings. All equipment including air-handling units, chilled and hot water pumps, and heat exchangers must be insulated in accordance with *ASHRAE Standard 90.1*. All pumps shall have jacketing.

Thermal Pipe Insulation for Plumbing Systems

All sanitary sewer vents terminating through the roof shall be insulated for a minimum of 1.83 meters (6 feet) below the roof line to prevent condensation from forming and include a vapor barrier jacket on this insulation. All Insulation materials and accessories shall comply with the fire and smoke hazard ratings indicated by ASTM-84, NFPA 255 and UL 723.

Domestic water piping shall be insulated in accordance with *ASHRAE 90.1*.

All piping exposed in plenums or above ceiling shall be insulated to prevent condensation. All insulation materials and accessories shall comply with the fire and smoke hazard ratings indicated by ASTM-E84, NFPA 255 and UL 723.

5.19 Vibration Isolation, Acoustical Isolation, and Seismic Design for Mechanical Systems

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

Mechanical Room Isolation. Floating isolation floors should be considered for major mechanical rooms located in penthouses or at intermediate levels in mid-rise and high-rise construction. See Chapter 3: *Architectural and Interior Design, Special Design Considerations, Acoustics, Design Criteria for Building Spaces, Class X Spaces*.

Mechanical Shafts and Chases. Mechanical shafts and 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. Shafts dedicated to gas piping must be ventilated.

Acoustical criteria for all building spaces are described in Chapter 3: *Architectural and Interior Design, Special Design Considerations, Acoustics*. For HVAC noise levels refer to Table 3-4, “Design Guidelines for HVAC-Related Background Sound in Rooms.”

Also, for design criteria, refer to “Selection Guide for Vibration Isolation,” *ASHRAE 99 Application Handbook, Chapter 46*.

Isolators. Isolators should be specified by type and by deflection, not by isolation efficiency. See *ASHRAE Guide for Selection of Vibration Isolators and Application Handbook* for types and minimum deflections. Specifications should be worded so that isolation performance becomes the responsibility of the equipment supplier.

Concrete Inertia Bases. Inertia bases should be provided for reciprocating and centrifugal chillers, air compressors, all pumps, axial fans above 300 RPM, and centrifugal fans above 37 kW (50 HP).

Ductwork. Reduce fan-generated noise immediately outside any mechanical room wall by acoustically coating or wrapping the duct. The ductwork design shall appropriately consider and address airborne equipment noise, equipment vibration, ductborne fan noise, duct breakout noise, airflow generated noise and ductborne crosstalk noise. All ductwork connections to equipment having motors or rotating components shall be made with 6-inch length of flexible connecters. All ductwork within the mechanical room or serving courtrooms shall be supported with isolation hangers.

Piping Hangers and Isolation. Isolation hangers should be used for all piping in mechanical rooms and adjacent spaces, up to a 15 m (50-foot) distance from vibrating equipment. The pipe hangers closest to the equipment should have the same deflection characteristics as the equipment isolators. Other hangers should be spring hangers with 20 mm (.75 inch) deflection. Positioning hangers should be specified for all piping 200 mm (8 inches) and larger throughout the building. Spring and rubber isolators are recommended for piping 50 mm (2 inches) and larger hung below noise sensitive spaces.

Floor supports for piping may be designed with spring mounts or rubber pad mounts. For pipes subject to large amounts of thermal movement, plates of Teflon or graphite should be installed above the isolator to permit horizontal sliding.

Anchors and guides for vertical pipe risers usually must be attached rigidly to the structure to control pipe movement. Flexible pipe connectors should be designed into the piping before it reaches the riser.

Noise Control in VAV Systems. System sound levels at maximum flow must be carefully evaluated to ensure acoustic levels required in Chapter 3. Inlet guide vanes should be evaluated for noise in their most restricted position. Duct noise control should be achieved by controlling air velocity, by the use of sound attenuators, by the use of double wall ductwork with insulation in-between (only on courtroom return air transfer grilles) and by not oversizing terminal units. Terminal units should be selected so that design air volume is approximately three-quarters of the terminal box's maximum capacity. Volume dampers in terminal units should be located at least 1.8 m (6 feet) from the closest diffuser and the use of grille mounted balance dampers should be restricted except for those applications with accessibility problems.

Noise Transmission Attenuation (Courthouses). Attenuate noise trans-mission to and from courtrooms, judges' chambers, jury rooms, prisoner consulting rooms and from prisoner detention areas.

5.20 Meters, Gauges, and Flow Measuring Devices

Thermometers and Gauges. Each piece of mechanical equipment shall be provided with the instrumentation or test ports to verify critical parameters, such as capacity, pressures, temperatures, and flow rates. Following are the general instrumentation requirements:

- Thermometers and pressure gauges are required on the suction and discharge of all pumps, chillers, boilers, heat exchangers, cooling coils, heating coils, and cooling towers. To avoid pressure gauge tolerance errors, a single pressure gauge may be installed, valved to sense both supply and return conditions. For coils with less than 10 gpm flow, provisions for use of portable instruments to check temperatures and pressures shall be made.

- Duct static pressure gauges shall be provided for the central air-handling unit air supply fan discharge, branch take-offs of vertical supply risers and at all duct locations at which static pressure readings are being monitored to control the operation of a VAV system.

- Differential static pressure gauges shall be placed across filters in air-handling units and to measure building pressure relative to the outdoors. A temperature gauge is required at the outside air intake to each air-handling unit.

Flow Measuring Devices. Airflow measuring grids are required for all central air-handling units. Measuring grids shall be provided at the supply air duct, return air duct, and the outside air duct. Airflow measuring grids must be sized to give accurate readings at minimum flow. It may be necessary to reduce the duct size at the station to permit accurate measurement.

Water flow or energy measuring devices are required for each chilled water refrigeration machine, hot water boiler, pump, and connections to district energy plants. Individual water flow or energy measuring devices shall be provided for chilled water lines serving computer rooms and chilled water and hot water lines to outleased spaces. Flow measuring devices shall be capable of communicating with the central BAS. Water flow and air flow measuring devices shall confirm or validate *ASHRAE 90.1* requirements.

Testing Stations. Permanent or temporary testing stations shall be provided for start up and testing of building systems. Connections shall be designed so temporary testing equipment can be installed and removed without shutting down the system.

Water Use Meters. See Section 5.24, *Plumbing Systems, Domestic Water Supply Systems,* in this chapter.

Indoor Air Quality Measurement. Vehicle garage exhaust fans shall generally be activated based upon carbon monoxide sensors within the garage. Carbon monoxide sensors shall also be located in all floor areas where vertical shafts penetrate the garage areas.

Table 5-6
Minimum Control and Monitoring Points for Typical HVAC Equipment

Central Air Handling Units Start/Stop Heating Control Cooling Control Humidification Control Supply Air Reset Static Pressure Reset Building and Zone Pressurization Control Damper Position (economizer) Supply Air Discharge Temp Return Air Temp Mixed Air Temp Supply Air Flow Rate Filter Differential Pressure Air Flow Measuring Station	**Refrigeration Equipment** Start/Stop Leave Water Temp Reset Demand Limiting Isolation Valve Position Leaving Water Temp Entering Water Temp kW Draw Flow Return Air Flow Rate	**Hot Water Boilers** Start/Stop Leaving Water Temp Reset Reset Isolation Valve Position Leaving Water Temp Entering Water Temp Flow BTU Draw
Cooling Towers Start/Stop Leaving Water Temp Reset Flow Isolation Valve Position Entering Water Temp Leaving Water Temp	**Terminal Boxes** Start/Stop Discharge Temp Reset Supply Volume Reset Heating Control Zone Temp Reset Minimum Volume Reset Zone Temp Supply Air Reset Zone Pressurization Control	**Pumps** Start/Stop Discharge Pressure Reset Differential Pressure Flow
Utilities Natural Gas Consumption Electricity Consumption & Demand Water Consumption Fuel Oil Quantity		

5.21 Control Systems

Automatic Temperature and Humidity Controls

A direct digital control (DDC) system with host computer controlled monitoring and control shall be provided.

Control Systems shall be BACnet or LONWORKS, conforming to ASHRAE BACnet Standard 135.

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

PID loops shall be utilized. All chillers, boilers, terminal units and air handling units shall have self-contained BACnet or LONWORKS controllers, capable of communicating with the Building Automation System.

Temperature Controls. Heating and cooling energy in each zone shall be controlled by a thermostat or temperature sensor located in that zone. Independent perimeter systems must have at least one thermostat or temperature sensor for each perimeter zone.

A 1.5°C (35°F) dead band shall be used between independent heating and cooling operations within the same zone.

Night set-back and set-up controls must be provided for all comfort conditioned spaces, even if initial building occupancy plans are for 24-hour operation. Morning warm-up or cool-down must be part of the control system. Controls for the various operating conditions must include maintaining pressurization requirements.

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

Temperature Reset Controls

Air Systems. Systems supplying heated or cooled air to multiple zones must include controls that automatically reset supply air temperature required by building loads or by outside air temperature.

Hydronic Systems. Systems supplying heated and/or chilled water to comfort conditioning systems must also include controls that automatically reset supply water temperatures required by temperature changes responding to changes in building loads (including return water temperature) or by outside air temperature.

5.22 Building Automation Systems (BAS)

BAS shall be direct digital control (DDC) for providing lower operating costs and ease of operation. Microprocessor PID controllers monitor and adjust building systems to optimize their performance and the performance with other systems in order to minimize overall power and fuel consumption of the facility, BAS monitor systems such as HVAC and lighting.

The system shall consist of series of direct digital controllers interconnected by a local area network. BAS system shall be accessible through a web browser. System shall have a graphical user interface and must offer trending, scheduling, downloading memory to field devices, real-time “live” graphic programs, parameter changes of properties, set point adjustments, alarm/event information, confirmation of operators, and execution of global commands.

A BAS is not required for every project and should be evaluated based on the size of the building. Buildings of 100,000 gsf. and more shall have a BAS. The size of the building, number of pieces of equipment, expected energy savings and availability of trained staff should all be considered before a decision is made. BAS is required and considered part of the system on large facilities (above 9,300 gross square meters (100,000 gross square feet)), both new facilities and major modernizations.

Level of Integration. Since the advent of micro-computer BAS systems, there has been an attempt to integrate as many systems as possible to reduce hardware requirements.

However, caution is advised when planning BAS systems with a high level of integration. The more integration, the more complex the system becomes and the more training is required for the operating staff. Also, reliability requirements for the different systems may vary.

Lighting control systems shall not be connected to BAS except for monitoring of lighting system.

Fire alarm systems, security systems and elevator systems shall not be controlled by a BAS. These systems should have independent control panels and networks. The BAS system shall monitor the status of these systems only, in order to prompt emergency operating modes of HVAC and lighting systems. See Chapter 7: *Fire Protection Engineering, Electrical Requirements, Fire Alarm Systems,* and *Chapter 8: Security Design.*

BAS shall utilize ‘open’ communication protocols, such as BACnet per *ASHRAE Standard 135*, to minimize the costs of providing integration and to allow interoperability between building systems and control vendors. Other open protocol language systems, such as LonTalk, may also be used, provided there is compatibility with overall regional and/or central monitoring and central strategies. A/E to specify and include functional design manual, hardware manual, software manual, operation manual, and maintenance manual. BAS shall have energy management and monitoring software.

In retrofits with an existing old-proprietary system in place, it is recommended that life cycle cost analysis determine between the complete replacement of the existing system or integrating the existing system with customized gateways. In the long term, with hardware and software costs falling as capabilities increase, energy savings are producing the paybacks required to justify the complete control retrofit.

Energy Conservation. The best targets for energy conservation in building systems are the HVAC system and the lighting system. HVAC control algorithms shall include optimized start/stop for chillers, boilers, air-handling units and all associated equipment and feed-forward controls based on predicted weather patterns. Lighting control shall be accomplished by use of separate control equipment, which allows BAS monitoring and reporting and control settings. Optimal start/stop calculates the earliest time systems can be shut down prior to the end of occupancy hours and the latest time systems can start up in the morning with the aim of minimizing equipment run time without letting space conditions drift outside comfort set points. Weather prediction programs store historic weather data in the processor memory and use this information to anticipate peaks or part load conditions. Programs also run economizer cycles and heat recovery equipment.

Maintenance Scheduling. The BAS shall include programs for control that switch pumps and compressors from operating equipment to stand-by on a scheduled basis. Also, programs that provide maintenance schedules for equipment in every building system shall be included, complete with information on what parts and tools are needed to perform each task.

System Design Considerations. BAS's require measurements at key points in the building system to monitor part-load operation and adjust system set points to match system capacity to load demands. Table 5-6 of the previous section outlines the minimum control and monitor points for typical HVAC equipment. Controls cannot correct inadequate source equipment, poorly selected components, or mismatched systems. Energy efficiency requires a design that is optimized by realistic prediction of loads, careful system selection, and full control provisions. System ability must include logs of data created by user selectable features. In new buildings and major renovations, the BAS shall have approximately 20 percent spare capacity for future expansion. The system must provide for stand-alone operation of subordinate components. The primary operator workstation shall have a graphical user interface. Stand-alone control panels and terminal unit controllers can have text-based user interface panels which are hand-held or fixed.

Energy Measurement Instrumentation. BAS shall have the capability to allow building staff to measure energy consumption and monitor performance which is critical to the overall success of the system. Electrical values, such as V, A, kW, KVAR, KVA, PF, kWh, KVARH, Frequency and Percent THD, shall be measured. See also Chapter 6: *Electrical Engineering, Site Distribution*, for separate metering of power consumption.

Energy management measurements shall be totalized and trended in both instantaneous and time-based numbers for chillers, boilers, air-handling units and pumps. Energy monitoring data shall be automatically converted to standard database and spreadsheet format and transmitted to a designated PC. Energy points are those points that are monitored to ensure compliance with *ASHRAE Standard 90.1*.

5.23 Startup, Testing, and Balancing Equipment and Systems

Startup. The A/E shall specify that factory representatives be present for startup of all major equipment, such as boilers, chillers and automatic control systems.

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 and Plumbing systems, in accordance with the design intent. The Testing and Balancing contractor shall have up to date certification by Associated Air Balance Council (AABC), the National Environmental Balance Bureau (NEBB), or the Testing, Adjusting, and Balancing Bureau (TABB).

Performance Testing. A/E to specify performance testing of all equipment and systems including chillers, boilers, and other systems for part load and full load during summer, winter, spring and fall season as per the schedules specified by the designer. A/E to specify the services of an organization certified by NEBB or AABC.

Pressure and Leak Testing. Tests shall be conducted at static pressures equal to maximum design pressure of system and maximum leakage allowable shall not exceed 50 percent of that allowed in SMACNA's HVAC Air Duct Leakage Manual.

A/E to specify IAQ testing for CO, CO2, volatile organic compounds, NO2, O3, and tobacco smoke. A/E to specify operating tests on each air and hydronic system to measure and meet energy efficiency requirements of *ASHRAE 90.1* and 62. A/E to specify and validate peak summer and winter energy consumption and performance.

5.24 Plumbing Systems

Water conservation shall be a requirement of all plumbing systems. Use water-saving plumbing fixtures.

Domestic Water Supply Systems

Cold Water Service. Cold water service shall consist of a pressurized piping distribution system incorporating a separate supply line from the tap in the existing outside water main to the equipment area inside the building.

Water service shall be metered inside the building by meters furnished by the local department of public works. Incoming service shall have double check valves. Remote reading of meters will be accomplished by special equipment over telephone lines. Irrigation systems must be sub-metered for deduct billing of the sewer system.

Internal distribution shall consist of a piping system that will supply domestic cold water to all necessary plumbing fixtures, water heaters and all mechanical make-up water needs.

Distribution system shall include equipment that will maintain adequate pressure and flow in all parts of the system in accordance with GSA Facilities Standards.

Triplex booster pumping system shall be utilized if the water pressure is not adequate to provide sufficient pressure at highest, most remote fixture. The water pressure at the fixture shall be in accordance with the International Plumbing Code.

Hot Water Service. Hot water shall be generated by heaters utilizing natural gas, electricity or steam as an energy source. Selection shall be supported by an economic evaluation incorporating first cost, operating costs and life cycle costs in conjunction with the HVAC energy provisions.

Instantaneous hot water heaters are not permitted as a primary source. Domestic hot water supply temperature shall be generated at 60°C (140°F), and shall be tempered to 49°C (120°F) using a three-way mixing valve, before supplying to all plumbing fixtures. Hot water supply to dishwashers shall be at 82°C (180°F), and the temperature shall be boosted from 60°C (140ºF) to 82°C (180°F). Heat pump hot water heaters shall be used where possible to save energy. For incidental use, the use of instantaneous hot water heaters is permitted.

Distribution system shall consist of a piping system, which connects water heater or heaters to all plumbing fixtures as required. Circulation systems or temperature maintenance systems shall be included. Hot water shall be available at the furthest fixture from the heating source within 15 seconds of the time of operation.

Domestic Water Supply Equipment. Domestic water supply equipment shall include, but not be limited to, the following equipment:

- Water heaters
- Pressure booster systems
- Pressure regulating valves
- Circulating pumps
- Back flow preventers
- Balancing valves
- Isolation valves
- Hangers and supports
- Thermal insulation

Water hammer arrestors shall be provided at every branch to multiple fixtures and on every floor for both hot and cold water.

Domestic cold and hot water distribution systems shall be insulated per *ASHRAE 90.1 and all exposed piping* shall have PVC jacketing.

Sanitary Waste and Vent System

Waste Pipe and Fittings. A complete sanitary collection system shall be provided for all plumbing fixtures, floor drains and kitchen equipment designed in compliance with applicable codes and standards. Piping shall be cast iron soil pipe with hub and spigot joints and fittings. Above ground piping may have no-hub joints and fittings.

Vent Piping and Fittings. System shall be the same as the waste piping above.

Floor Drains. Floor drains shall be provided in multi-toilet fixture restrooms, kitchen areas, mechanical equipment rooms, locations where condensate from equipment collects, and parking garages and ramps. Single fixture toilet rooms do not require floor drains.

In general, floor drains shall be cast iron body type with 6 inch diameter nickel-bronze strainers for public toilets, kitchen areas and other public areas. Equipment room areas will require large diameter cast iron strainers and parking garages will require large diameter tractor grates. Drainage for ramps will require either trench drains or roadway inlets when exposed to rainfall. Trap primers shall be provided for all floor drains where drainage is not routinely expected from spillage, cleaning, or rainwater.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Sanitary Waste Equipment. Specific drains in kitchen areas shall discharge into a grease interceptor before connecting into the sanitary sewer in accordance with the requirements of the state health department and local authorities will determine which drains. Floor drains and/or trench drains in garage locations are to discharge into sand/oil interceptors.

Automatic Sewage Ejectors. Sewage ejectors should only be used where gravity drainage is not possible. If they are required, only the lowest floors of the building should be connected to the sewage ejector; fixtures on upper floors should use gravity flow to the public sewer. Sewage ejectors shall be non-clog, screenless duplex pumps, with each discharge not less than 100 mm (4 inches) in diameter. They shall be connected to the emergency power system.

Rainwater Drainage System

Pipe and Fittings. Piping system shall be in compliance with local codes and sized based upon local rainfall intensity.

Roof Drains. Roof drains shall be cast iron body type with high dome grates and membrane clamping rings, manufactured by any of the major foundries. Each roof drain shall have a separate overflow drain located adjacent to it. Overflow drains will be the same drains as the roof drains except that a damming weir extension will be included.

Rainwater Drainage Equipment. Foundations drainage system with perforated drain tile collecting into a sump containing a pumping system as required by the applicable codes shall be provided.

Plumbing Fixtures

General. Provide all required plumbing fixtures including those that are indicated in the U.S. Courts Design Guides and all penal types. Fixtures shall be manufactured by companies that are approved by General Services Administration or their representatives.

All fixtures shall have sensing devices for saving water.

Natural Gas Systems

Service Entrance. Gas piping entering the building must be protected from accidental damage by vehicles, foundation settlement or vibration. Where practical, the entrance should be above grade and provided with a self-tightening swing joint prior to entering the building. Gas piping shall not be placed in unventilated spaces, such as trenches or unventilated shafts, where leaking gas could accumulate and explode.

Gas Piping within Building Spaces. Gas shall not be piped through confined spaces, such as trenches or unventilated shafts. All spaces containing gas-fired equipment, such as boilers, chillers and generators, shall be mechanically ventilated. Vertical shafts carrying gas piping shall be ventilated. Gas meters shall be located in a gas meter room, thus avoiding leakage concerns and providing direct access to the local gas utility.

All gas piping inside ceiling spaces shall have plenum rated fittings.

Diaphragms and regulators in gas piping must be vented to the outside.

Fuel Oil Systems

Fuel Oil Piping. Fuel oil piping system shall use at least Schedule 40 black steel or black iron piping. Fittings shall be of the same grade as the pipe material. Valves shall be bronze, steel or iron and may be screwed, welded, flanged or grooved. Double-wall piping with a leak detection system shall be used for buried fuel piping.

Duplex fuel-oil pumps with basket strainers and exterior enclosures shall be used for pumping the oil to the fuel burning equipment.

Underground Fuel Oil Tanks. Underground fuel oil storage tanks shall be of double wall, non-metallic construction or contained in lined vaults to prevent environmental contamination. Tanks shall be sized for sufficient capacity to provide 48 hours of system operation under emergency conditions (72 hours for remote locations such as border stations). For underground tanks and piping a leak detection system, with monitors and alarms for both, is required. The installation must comply with local, State and Federal requirements, as well as EPA 40 CFR 280 and 281.

Fire Protection

Refer to Chapter 7: *Fire Protection Engineering.*

5.25 Alterations in Existing Buildings and Historic Structures

The goal of alteration projects is to meet the same standards described in this document for new projects. Equipment/systems at 20 years life or older must be demolished and new systems designed to meet the current usage of the facility. Renovation and rehabilitation designs must satisfy the immediate occupancy needs and anticipate additional future changes. Remodeling should make building systems become more flexible, not less. Parameters of reuse and disruption of service must be clearly specified in construction documents.

Alteration projects can occur at three basic scales: refurbishment of an area within a building, such as a floor or a suite; major renovation of an entire structure; and up-grade/restoration of historic structures.

In the first instance, the aim should be to satisfy the new requirements within the parameters and constraints of the existing systems. The smaller the area in comparison to the overall building, the fewer changes to existing systems should be attempted. In the second case, the engineer has the opportunity to design major upgrades into the mechanical, electrical and communications systems. The mechanical services can come close to systems that would be designed for a new building, within the obvious limits of available physical space and structural capacity.

Where a historic structure is to be altered, special documents will be provided by GSA to help guide the design of the alterations. The most important of these is the HBPP that identifies zones of architectural importance, specific character-defining elements that should be preserved, and standards to be employed. *See Chapter 1: General Requirements, General Design Philosophy, Historic Buildings.*

Modern standards for climate control developed for new construction may not be achievable or desirable for historic buildings. In each case, the lowest level of intervention needed to successfully accomplish the project should be selected. When a system is designed, it is important to anticipate how it will be installed, how damage to historic materials can be minimized, and how visible the new mechanical system will be within the restored or rehabilitated space.

The following guidelines should be followed for HVAC work in historic buildings:

- Reduce heating and cooling loads to minimize size and other impacts of modern equipment.
- Calculate the effect of historic building features such as wall thickness, skylights, and porticos, interior design features such as draperies, shutters and window shades, and existing site features such as landscaping.
- Add insulation where not visible and intrusive, such as attics or basements. Insulate walls only where it can be done without removal or covering of original visible elements.

- Add storm windows where they can be installed in a manner that will not detract from original visible elements.
- Use new replicated thermal windows only where it is not economically feasible to repair existing windows.
- Select system types, components, and placement to minimize alteration of significant spaces. In previously altered spaces, design systems to allow historic surfaces, ceiling heights, and configurations to be restored. Consider reuse of existing components when reuse will reduce architectural intrusion and achieve savings, without compromising overall performance and life cycle requirements. Reuse of HVAC system elements is only permitted with written documentation obtained from GSA Property Management by the A/E. Retain decorative elements of historic systems where possible. Ornamental grilles and radiators and other decorative elements shall be retained in place.
- Retain the original type of system where a new one cannot be totally concealed. For example, reuse existing radiators with new distribution piping or replace with modern heating-cooling units, rather than adding another type of system that would require the addition of new ceilings or other non-original elements.
- Use a number of smaller units in lieu of a few large ones. Insure that room is available to maintain and replace equipment without damaging significant features to the greatest extent possible, selecting components that can be installed without dismantling window or door openings.
- Place new distribution systems out of sight whenever possible by using closets, shafts, attics and basements.
- Use custom rather than commercial standard products where elements are exposed in formal areas.
- Select temperature and humidity conditions that will not accelerate deterioration of building materials.
- Where equipment is near significant features, insure that leakage from pipes and HVAC units will not cause deterioration. Use deeper condensate drain pans, lined chases and leak detectors.
- Design HVAC systems to avoid impacting other systems and historic finishes, elements and spaces.
- Place exterior equipment where it is not visible. Be particularly careful with new chimneys or vents and condensers, towers, solar panels and air intakes and discharges. Recess equipment from the edge of the roof to minimize visibility of the equipment from grade. Alternatively, explore creating a vault for easier access to large mechanical equipment. If equipment cannot be concealed, specify equipment housings in a color that will blend with the historic face. As a last resort, enclose equipment in screening designed to blend visually with the facade.
- Locate equipment with particular care for weight and vibration on older building materials. These materials may not accept the same stress as when the equipment is used in newer construction.

- If new ceilings must be installed, insure that they do not block any light from the top of existing windows or alter the appearance of the building from the outside. This is the area of highest natural illumination, and it can be used to reduce the need for artificial illumination, which will in turn reduce the size of HVAC systems. Original plaster ceilings in significant spaces such as lobbies and corridors should be retained, to the extent possible, and modified only as necessary to accommodate horizontal distribution. Use soffits and false beams where necessary to minimize alteration of overall ceiling heights.

- Locate pipes so that they do not damage or visually interfere with character-defining elements in historic structures such as windows, doors, columns, beams, arches, baseboards, wainscots, paneling, cornices, ornamental trim, decorative woodwork and other decorative treatments of doors, walls and ceilings.

- Vertical Distribution. If new risers are required, they should preferably be located adjacent to existing shafts.

- Horizontal Distribution. Many older buildings have high floor-to-floor heights, which permit an option to use an existing ceiling space.

- In buildings containing ornamental or inaccessible ceilings, piping and ductwork may have to be routed in furred wall space or exposed in the occupiable building area. Exposed ducts must be designed to complement the building architecture in forms and materials used. Use of exposed ducts is encouraged in locations where concealing ducts would obscure significant architectural surfaces or details, such as vaulted ceilings. Exposed ducts should also be considered in historic industrial buildings and open plan, tall ceiling, high window spaces suited to flexible grid/flexible density treatments.