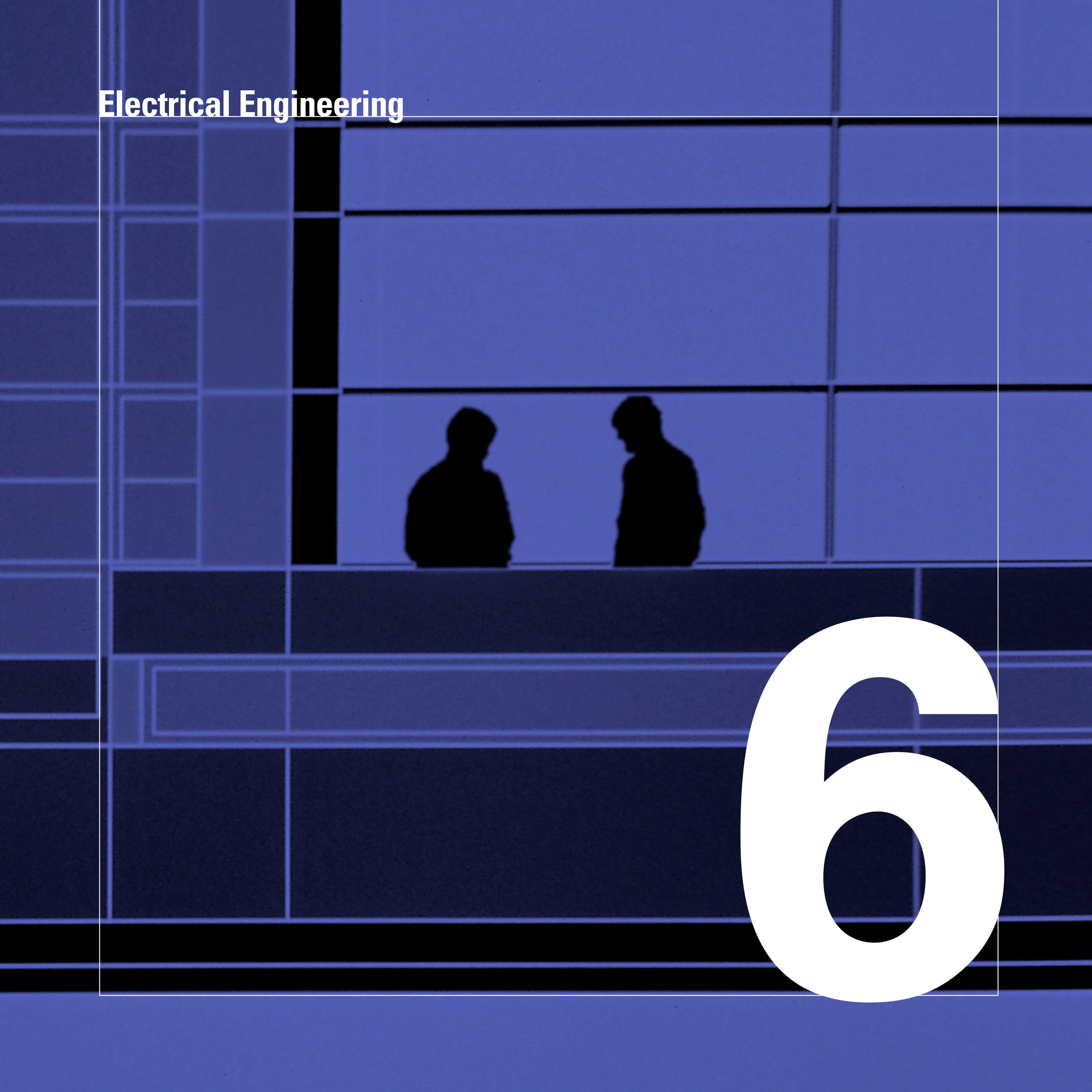


Electrical Engineering

6

6.0 TABLE OF CONTENTS

6.1 General Approach

Electrical and communications systems in GSA buildings provide the infrastructure for an efficient work environment for the occupants. These systems must support the many types of equipment used in a modern office setting in a reliable fashion.

There are three characteristics that distinguish GSA buildings: long life span, changing occupancy needs, and the use of a life cycle cost approach to account for total project cost.

GSA owns and operates its buildings much longer than the private sector. Consequently, a higher level of durability is required for all systems, as is the ability to replace equipment during the life of the building.

During the life span of a typical Federal building, many minor and major alterations are necessary as the missions of Government agencies change. The flexibility to adjust to alterations easily must be designed into the building systems from the outset. Electrical and communications systems should provide ample capacity for increased load concentrations in the future and allow modifications to be made in one area without causing major disruptions in other areas of the facility.

It is GSA's goal to build facilities equipped with the latest advances in office technology and communication. This intent should be extended to include the future evolution of automated office and telecommunications equipment as well. Making this concept a reality requires a comprehensive design for engineering systems that goes beyond the requirements of the immediate building program. It also requires a higher level of integration between architecture and engineering systems than one would usually expect in an office building.

The trend toward intelligent buildings is gaining momentum in the Federal sector. The Government recognizes that communications needs and technology are growing at an increasingly rapid pace. Work stations are becoming more powerful, requiring faster and easier access to more information. GSA must install the wiring and interfaces to support these requirements. It should be noted that the design of all communications systems is the responsibility of GSA's Federal Technology Service (FTS).

A computer-based building automation system (BAS) that monitors and automatically controls lighting, heating, ventilating and air conditioning is critical to the efficient operation of the modern Federal office building. GSA encourages integration of building automation systems generally. Exceptions are the fire alarm and security systems, which shall function as stand-alone systems with a monitoring only interface to the BAS.

Architects and engineers should always make environmentally responsible choices regarding new building materials and the disposal of discarded products. Recycled material use needs to be maximized to the fullest extent practical within the project requirements. Architects and engineers should consider integrating renewable energy technologies such as photovoltaics and other solar applications, geothermal heat and wind into building systems.

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

Submission Requirements, Every project will have unique characteristics and requirements for submission and review. These shall be developed by the GSA Project Manager. The general submission requirements for each phase of project development are described in Appendix A.

Ronald Reagan Building, Washington, D.C.

6.2 Codes and Standards

Model codes and standards adopted by GSA are discussed in Chapter 1: *General Requirements, Codes and Standards, Building Codes*. All electrical and communications systems must meet or exceed the requirements of the National Electric Code (NEC).

Electrical Design Standards

The standards listed below are intended as guidelines for design only. They are mandatory only where referenced as such in the text of the chapter. The list is not meant to restrict engineers from using additional guides or standards as desired.

- Federal Information Processing Standard 175: *Federal Building Standard for Telecommunication Pathways and Spaces* (see also EIA/TIA Standard 568-A and related bulletins)
- Federal Information Processing Standard 174-1: *Federal Building Telecommunications Wiring Standard* (see also EIA/TIA Standard 569 and related bulletins)
- Federal Information Processing Standard 176: *Residential and Light Commercial Telecommunications Wiring Standard* (see also EIA/TIA Standard 570 and related bulletins)
- Federal Information Processing Standard 187: *The Administration Standard for Telecommunications Infrastructure of Federal Buildings* (see also EIA/TIA Standard 606 and related bulletins)
- Federal Information Processing Standard 195: *Federal Building Grounding and Bonding Requirements for Telecommunications* (see also EIA/TIA Standard 607 and related bulletins)

6.3 Placing Electrical Systems and Communications Systems in Buildings

In order to achieve system flexibility and thorough integration between building architecture and engineering systems, a concept for the power and telecommunications infrastructure that supports the distribution of electrical and communications systems must be established during the architectural schematic design. The locations of vertical backbone pathways, horizontal pathways, closets, equipment rooms and utility entrance facilities for electrical and communications distribution equipment must be established before the architectural concept is finalized.

Electrical Closets . The spacing of electrical and communications closets in buildings is described in Chapter 3: *Architectural and Interior Design, Building Planning, Placement of Core Elements and Distances*.

Communications Closets. Communications closets shall meet the requirements of FIBS Standard 175: *Federal Building Standard for Telecommunications Pathways and Spaces*. The location and size of communications closets are discussed in Chapter 3: *Architectural and Interior Design*.

Planning Grid, Floor Grid and Ceiling Grid. A common planning grid is to be used in all GSA buildings. Electrical and communications elements in floors and ceilings including lights, power, telephone and data are given precise locations within the planning grid. The relationship of this grid to wall placement, ceiling grids and location of mechanical and electrical elements is described in detail in Chapter 3: *Architectural and Interior Design, Building Planning, Planning Grid*.

Horizontal Distribution of Power and Communications. In new construction the building shall have raised access flooring. In buildings with access flooring, power circuits should be provided via conduit, modular wire distribution boxes and modular wire cable sets to flush floor receptacles. Communication cables can be laid exposed directly on the slab and grouped together in rows 3600 mm (12 feet) on center.

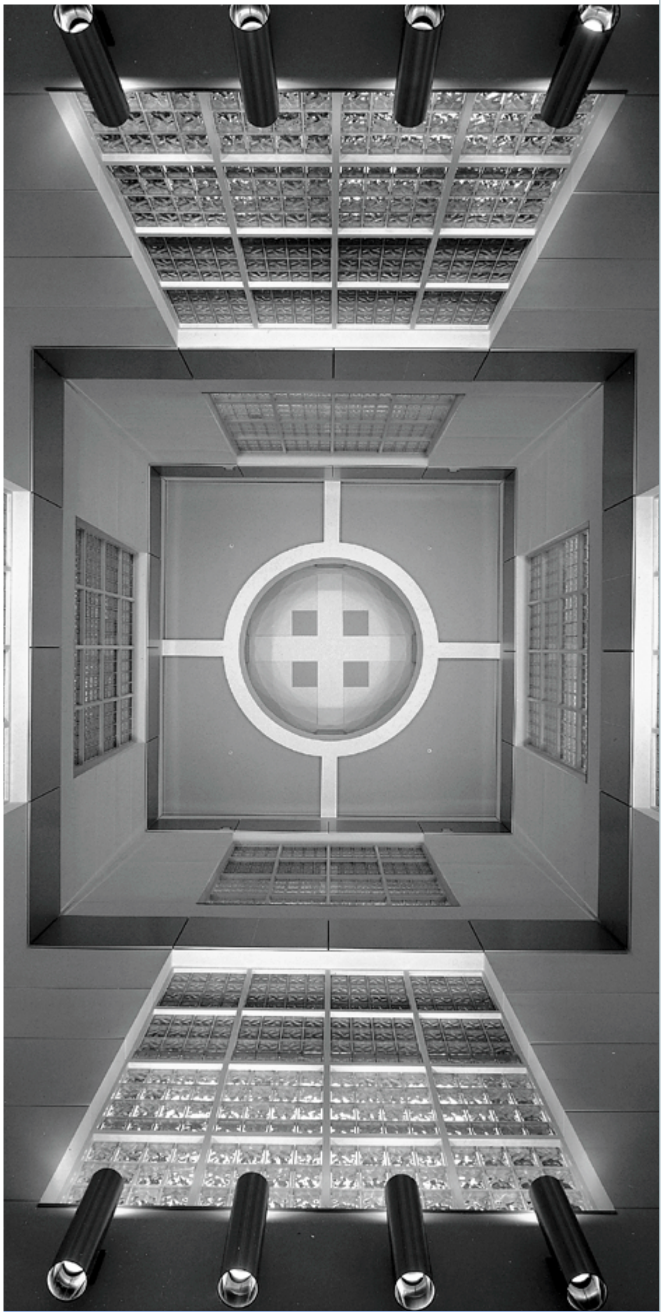
Power, data and telephone cables shall be grouped together in pathways that are separated into channels for each system. Independent channels are required in horizontal pathways for normal power, emergency power, mechanical, fire alarm, security, television and communications. The communications channel includes voice and data. Major zones within the facility should have horizontal distribution capacity for all seven categories described above. Horizontal pathways serving individual work stations must have at least three channels for power, voice and data. FIBS 175: *Federal Building Standard for Telecommunication Pathways and Spaces* provides detailed requirements for communications pathways, including requirements for underfloor ducts, access floor, conduit, cable trays and wireways, ceiling pathways and perimeter pathways. Provide at least 650 mm^2 (1 square inch) of horizontal capacity for power and communications to office areas for every 10 m^2 (100 square feet) of occupied area.

The placement of outlets in walls or in the partitions of systems furniture should be avoided because of the difficulty it creates for future reconfiguration of the office space. This is true for both closed office and open plan concepts. Light switches likewise should be located on columns and the walls of fixed core elements, to the maximum extent possible.

Flat conductors, poke-through and/or power poles shall not be used in new construction.

These criteria apply to all occupiable area or net usable space in a GSA building but not to public spaces or support spaces, which can be considered fixed elements and are not subject to frequent changes.

Vertical Distribution. Risers for normal power, emergency power and communications should be combined with other core elements to form compact groups and maximize usable floor space. The number and size of risers will depend on the systems chosen, but future flexibility should be an important criterion in the vertical layout as well. Electrical and communication closets shall be vertically stacked. Electrical closets shall have two capped 4-inch spare sleeves through the structural floor for future flexibility. Communications closets shall also have two capped spare sleeves in each closet. Vertical risers for normal power, emergency power, and communications should be aligned throughout the building to minimize conduit bends and additional cabling. Be aware of the requirements to locate fire alarm vertical risers remotely.



U.S. Courthouse, Kansas City, KS

6.4 General Design Criteria

Energy Conservation. Code requirements for energy conservation are detailed in Chapter 1: *General Requirements, Codes and Standards, Mandatory Design Standards, Energy Conservation Standards*. The largest factor in the energy consumption of a building is lighting. The overall efficiency of the lighting system depends both on the individual components and on the interaction of components in a system. A good controls strategy that eliminates lighting in unoccupied spaces and reduces it where daylighting is available can contribute significantly to energy conservation. The best way to institute such controls is through a Building Automation System (BAS). See section on *Lighting, Lighting Controls* in this chapter for further discussion. Designers should check with local power companies and include technologies that qualify for rebates.

Visual Impact. Options regarding the location and selection of electrical work that will have a visual impact on the interior and exterior of the building should be closely coordinated with the architectural design. This includes colors and finishes of lights, outlets and switches.

Equipment Grounding Conductor. All low voltage power distribution systems should be supplemented with a separate, insulated equipment grounding conductor. Grounding for communication systems must follow the requirements in the Federal Information Processing Standard 195: *Federal Building Grounding and Bonding Requirements for Telecommunications* (see also EIA/TIA Standard 607 and related bulletins).

Lightning Protection. Lightning protection should be evaluated in accordance with NFPA 78. Buildings in the "moderate to severe" category of exposure and higher shall be equipped with a UL listed lightning protection system. The system should be carefully designed to ensure that static discharges are provided with an adequate path to ground. Surge arresters on the main electrical service should also be considered.

Cathodic Protection. The need for corrosion protection for conduits and for all other underground piping and buried metals on the project must be evaluated through soil resistivity and pH testing. Testing for soils resistivity is part of the Geotechnical Report. See Appendix A: *Submission Requirements*. Cathodic protection should be designed by a qualified specialist.

6.5 Electrical Load Analysis

In establishing electrical loads for Federal buildings it is important to look beyond the immediate requirements stated in the project program. Future moves and changes have the effect of redistributing electrical loads. The minimum connected receptacle loads indicated in Table 6-1 combined with other building loads multiplied by appropriate demand factors, and with spare capacity added, shall be used for obtaining the overall electrical load of the building. If the load requirements stated in the program are higher, the program requirements must, of course, be satisfied.

Standards for Sizing Equipment and Systems

To ensure maximum flexibility for future systems changes, the electrical system must be sized as follows: panelboards for branch circuits must be sized with 50 percent spare ampacity, panelboards serving lighting only with 25 percent space switchboard ampacity, distribution panels with 35 percent spare ampacity and main switchgear with 25 percent spare ampacity. Spare overcurrent devices shall be provided as well as bus extension for installation of future protective devices.

Table 6-1
Minimum Connected Receptacle Load

	Minimum connected receptacle load	
Type of occupiable area	**Load per square meter**	**Load per square foot**
Normal systems		
Office/Workstation	14 VA	1.3 VA
Non-workstation areas such as public and storage	10 VA	1 VA
Core and Public areas	5 VA	0.5 VA
Electronic systems		
Office/Workstation	13 VA	1.2 VA
Computer rooms	700 VA	65 VA
NOTE: Normal and electronic equipment systems are as shown on Figure 6-6		

6.6 Utility Coordination and Site Considerations

Power Company Coordination. See Chapter 2: *Site Planning and Landscape Design, Site Utilities, Utilities Services.*

These data must be established prior to initial system design. Electrical load estimates must be prepared in conjunction with utility company discussions to establish the capacity of the new electrical services.

The service entrance location for commercial electrical power should be determined concurrently with the development of conceptual design. Space planning documents and standards for equipment furnished by utility companies should be incorporated into the concept design. Locations for transformers, vaults, meters and other utility items must be coordinated with the architectural design to avoid detracting from the building's appearance.

Site Considerations. The routing of site utilities and location of manholes should be determined early in the design process.

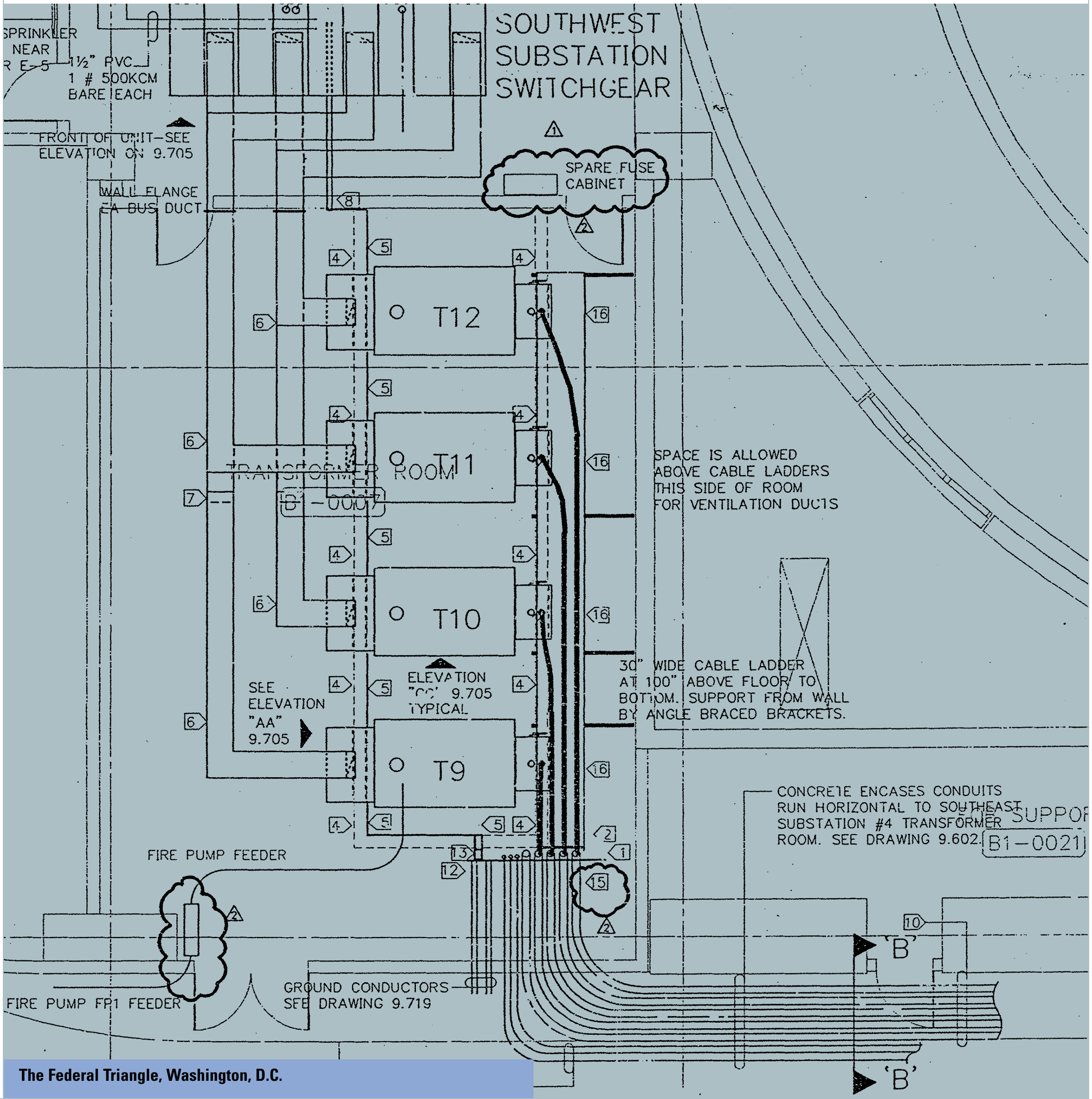
It is desirable to have the utility company furnish power at the main utilization voltage, i.e., 480/277V or 208/120V (for small buildings). GSA prefers that the utility company own and maintain the transformers.

In the case of large buildings or buildings with large footprints, it may be necessary to have more than one service. In large office buildings and in campus situations, it may also be necessary to distribute medium voltage power. If available, medium voltage, up to 15KV, should be used for primary power distribution to substations.

Communications Service Coordination. All communications systems within the building are designed, installed and operated under the management of the Office of the Chief Information Officer (I).

(I) contracts for service to GSA buildings. The engineers involved in the building design must coordinate their work with (I), and the telephone company having jurisdiction (not directly with the telephone company).

(I) will provide space requirements for telephone switch or PABX rooms and furnish information on any other design requirements.



The Federal Triangle, Washington, D.C.

6.7 Site Distribution

Exterior distribution systems must be either direct buried conduit or concrete encased conduit systems. Cable selection should be based on all aspects of cable operation and the installation environment, including corrosion, ambient heat, rodent attack, pulling tensions, and potential mechanical abuse and seismic activity.

Direct Buried Conduit. Direct buried PVC, coated intermediate metallic conduit (IMC) or rigid galvanized steel (RGS) is appropriate for the distribution of branch circuits. Direct buried cable should not be used.

Concrete-Encased Ductbank. Concrete-encased ductbanks should be used where many circuits follow the same route, for runs under permanent hard pavements and where service reliability is paramount, such as service entrances.

Duct line routes should be selected to balance maximum flexibility with minimum cost and to avoid foundations of other buildings and other structures. Ducts should be provided with a cover of at least 600 mm (24 inches). Ductbanks under railroads should be reinforced. Ducts should slope 4 percent toward manholes. Changes in direction should be by sweeps with a radius of 7.5 m (25 feet) or more. Stub-ups into electrical equipment may be installed with manufactured elbows. Duct line routes should be selected to balance maximum flexibility with minimum cost and to avoid foundations of other buildings and other structures. Ducts should be provided with a cover of at least 24 inches. Ductbanks under railroads should be reinforced. Ducts should slope 4 percent toward manholes. Changes in direction should be by sweeps with a radius of 25 feet or more. Stub-ups into electrical equipment may be installed with manufactured elbows.

Where it is necessary to run communication cables alongside power cables, two separate systems must be provided with separate manhole compartments. The same holds true for normal and emergency power cables. Ductbanks should be spaced at least 300 mm (1 foot) apart. Site entrance facilities including ductbanks and manholes must comply with requirements stated in Federal Information Processing Standard 175: *Federal Building Standard for Telecommunication Pathways and Spaces* (see also EIA/TIA [Electronic Industrial Association/Telecommunication Industry Association] Standard 568-A and related bulletins)

Electrical and communication ducts should be kept clear of all other underground utilities, especially high temperature water or steam.

Duct Sizes. Ducts should be sized as required for the number and size of cables. Inner ducts must be provided inside communication ducts wherever fiber optic cables will be used. A sufficient number of spare ducts should be included for planned future expansion; in addition, a minimum of 25 percent spare ducts must be provided for unknown future expansion.

Manholes. Manholes should be spaced no farther than 150 m (500 feet) apart for straight runs. The distance between the service entrance and the first manhole should not exceed 30 m (100 feet). Double manholes should be used where electric power and communication lines follow the same route. Separate manholes should be provided for low and medium voltage systems. Manholes should have clear interior dimensions of no less than 1800 mm (6 feet) in depth, 1800 mm (6 feet) in length, and 1800 mm (6 feet) in width with an access opening at the top of not less than 750 mm (30 inches) in diameter. Manholes must have a minimum wall space of 1800 mm (6 feet) on all sides where splices are to be racked.

Stubs. Minimum of two spare stubs should be provided (to maintain a square or rectangular ductbank) so that the manhole wall will not need to be disturbed when a future extension is made. Stubs for communications manholes must be coordinated with FTS.

Smaller manholes may be used for low voltage feeders (600V and below), branch circuits or communications circuits. They should be not less than 1200 mm (4 feet) in depth, 1200 mm (4 feet) in length, and 1200 mm (4 feet) in width with a standard manhole cover and sump of the same type provided for manholes. Generally, at least four racks should be installed. Where more than two splices occur (600V feeders only), a 6 feet by 6 feet by 6 feet manhole may be more appropriate.

6.8 Primary Distribution

The selection of a primary distribution system, i.e., radial, loop, primary selective, secondary selective, network, etc., should be evaluated on a case by case basis, with consideration given first to safety, then to cost and reliability. Generally, radial or loop systems are preferred.

The primary distribution system design should be based on the estimated demand load plus 25 percent spare capacity.

Medium Voltage Switchgear. When required, medium voltage service switchgear may be provided with either air, vacuum or SF6 circuit breakers or fused air interrupter switches. Provide voltmeter, ammeter and watt-hour meter with demand register. Meters should be pulse-type for connection to the BAS. Providing a power monitoring and management system is an acceptable option.

Conductors. Conductors should be insulated with cross linked polyethylene (XLP) or ethylene propylene rubber (EPR). 133 percent insulation should be provided. Conductor size should not exceed 240 mm^2 (500 Kcmil).

Spot Network Transformers. In cases where reliability is an absolutely critical concern - the IRS office that processes refund checks, for example - network transformers should be considered. In large cities, where load densities are very high, utility companies may choose to supply power through network transformers. If so, these systems should be utility owned and maintained.

Double-ended Substations. If reliability is critical and spot networks cannot be provided by the utility, double-ended substations should be used. Transformers may be equipped with fans to increase the rated capacity. The sum of the estimated demand load of both ends of the substation must not exceed the rating of either transformer, and it must not exceed the fan cooling rating. All double-ended substations should be equipped with two secondary main breakers and one tie breaker set up for open transition automatic transfer.

Transformers

Substation transformers must be dry-type with epoxy resin cast coils or silica oil filled type. Liquid filled transformers may be used outdoors. Substations should be located at least 30 m (100 feet) from communications frame equipment to avoid radio frequency interference. Provide lightning arrestors on the primary side of all transformers. Consider surge suppression on the secondary and/or downstream busses.

Transformers located in underground vaults must not be positioned directly adjacent to or beneath an exit way.

Where silica oil filled transformers are used, the design must comply with all spillage containment and electrical code requirements.

6.9 Secondary Distribution

Main Switchboards. 208V and/or 480V service switchboards as well as substation secondary switchboards should be provided with a single main service disconnect device. This main device should be molded case, insulated case, power air circuit breaker or fusible switch (where appropriate) individually mounted, draw-out type (as applicable). Insulated case and power air circuit breakers should be electrically operated.

The meter section should contain a voltmeter, ammeter and watt-hour meter with demand register. Meters should be pulse type for connection to the BAS. Providing a power monitoring and management system is an acceptable option.

Feeder devices of switchboards 2,000 AMPS and larger should be molded case, insulated case, power air circuit breakers or fusible switches where appropriate, individually mounted, draw-out type as applicable and electrically operated. Feeder devices of switchboards below 2,000 AMPS may be group-mounted, molded case circuit breakers or fusible switches.

Switchboards should be front and rear accessible. In smaller switchboards, front access only is acceptable if space is limited.

Grounding. All grounding systems must be carefully coordinated, especially in regard to: NEC grounding electrode systems; lightning protection; communications grounding; and computer room signal reference guide. Power distribution system grounding must be in accordance with Article 250 of the *National Electrical Code*. Also reference general design criteria (this chapter) for equipment grounding conductor. Grounding for communications systems must follow the requirements in the Federal Information Processing Standard 195: *Federal Building Grounding and Bonding Requirements for Telecommunications* (see also EIA/TIA Standard 607 and related bulletins).

Ground Sources. The ground source for the electrical power system must have a maximum resistance to ground of 5 ohms, except in small buildings i.e. less than 5000 m^2 (50,000 square feet) that have only minimal communications systems. Grounding systems for these buildings may have a resistance up to 10 ohms. The grounding design must be based on a soils resistivity test and ground resistivity calculations. Below-grade connections should be exothermically welded.

A wall-mounted, 6 mm by 50 mm (0.25-inch by 2-inch) copper ground bus should be provided in each electrical room. The ground bus should be located in the rear access aisle of the room and should extend at least 1 m (3 feet). It should be interconnected with the ground electrode and ground bus in the switchgear or switchboard.

Isolated Grounding Panels. Provide separate panels for computer loads to separate from general electrical loads in lieu of an IG system which is more complex and prone to mis-wiring.

Submetering. Electric power meters must be provided on the services to all spaces planned to be outleased, to all computer rooms and to the parking garage, if any.

Power Factor Correction. If the utility rate structure has a power factor penalty, non-PCB centralized automatic power factor capacitors should be connected at the main electrical service on the load side of the utility metering. Power factor capacitors should be designed to automatically correct a lagging power factor to a value that will avoid penalty charges. Switching circuits should be specifically designed to prevent electrical noise from entering the electrical power distribution system.

Motor Control Centers. Grouped motor controls should be used where more than six starters are required in an equipment room. Motor control center construction should be NEMA Class I, Type B with magnetic (or solid state if appropriate) starters and either circuit breakers or fuses. Minimum starter size should be size 1 in motor control centers. Each starter should have three overload relays. Control circuit voltage should be 120V connected ahead of each starter via control transformer as required.

Reduced voltage starters may be used for larger motors to reduce starting KVA.

In the design of motor control centers on emergency power, time delay relays should be considered to reduce starting KVA on the generator.

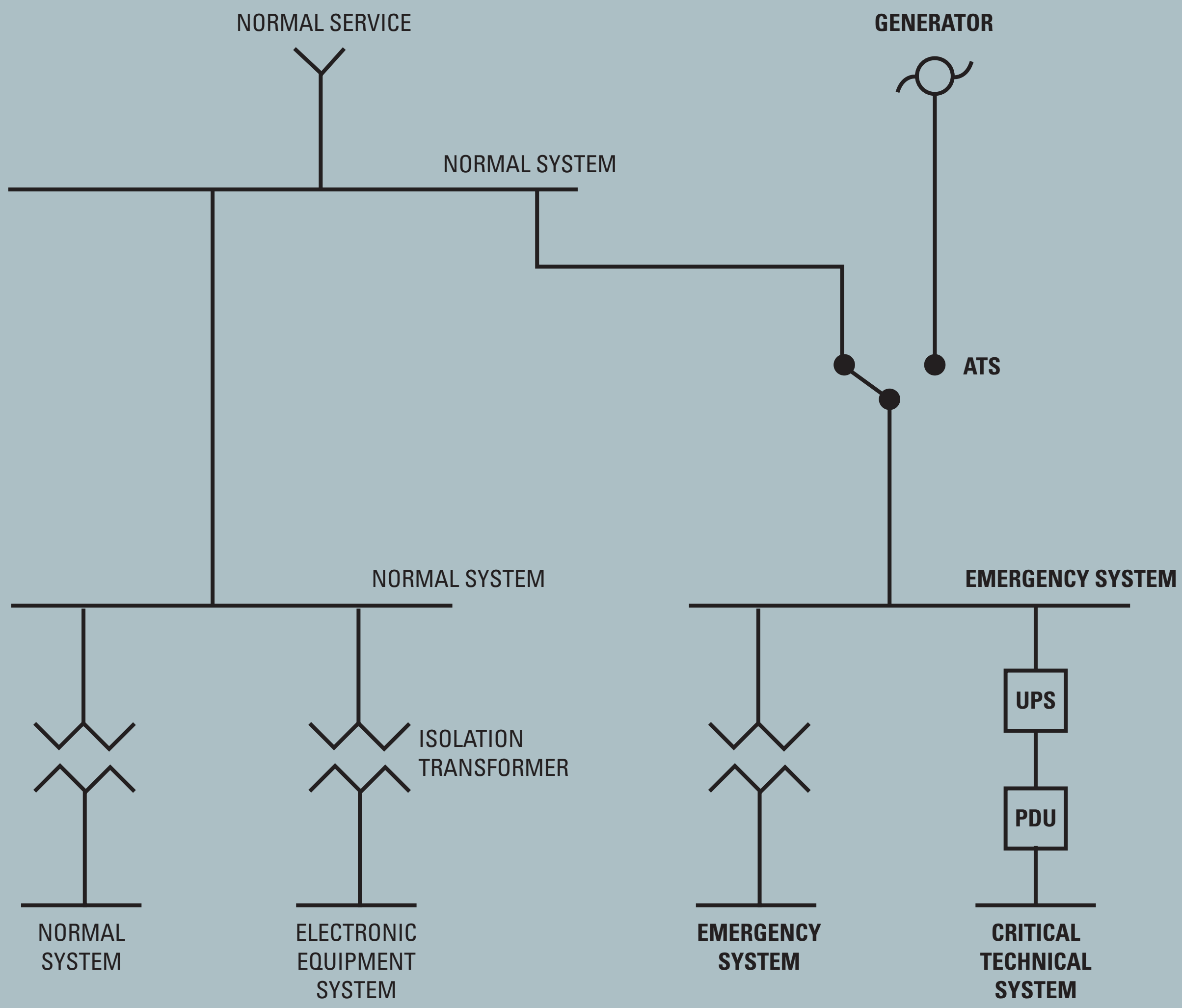
Elevator Power. Elevators should be powered from a shunt trip circuit breaker located in the elevator machine rooms. Electrical design standards in elevator standard ANSI/ASME A17.1 must be followed.

Secondary Distribution Systems

Secondary electrical power distribution systems in Federal buildings are classified as normal, emergency and uninterruptible. Normal power serves the general power and lighting loads in the building. Emergency power is distributed to life safety and critical loads. Uninterruptible power is required for critical loads, which cannot be interrupted.

In typical GSA office buildings it is recommended that 208/120V normal power be subdivided to isolate the office electronic equipment load. Figure 6-6 shows a typical power distribution scheme.

Figure 6.6 Typical Power Distribution Scheme



Bus Duct. Where plug-in bus duct is used, it should have an integral ground bus, sized at 50 percent of the phase bus to serve as the equipment grounding conductor.

Conductors. Aluminum or copper conductors are acceptable for motor windings, transformer windings, switchgear bussing, switchboard bussing and bus duct, where the conductor is purchased as part of the equipment. Aluminum conductors shall not be used for primary feeders, branch feeding or branch circuits.

Power Distribution Panels. In general, circuit breaker type panels will be the standard of construction for federal buildings. With the exception of lighting and receptacle panel boards, fusible switches may be considered if specific design considerations warrant their application, such as in electrical coordination of electrical over-current devices.

Lighting and Receptacle Panelboards. Lighting and receptacle panelboards shall be circuit breaker type. Provide minimum 30 poles for 100 amps panelboards and minimum 42 poles for 225 amp panelboards.

Lighting panelboards shall have minimum of three 20-amp 1-pole spare circuit breakers.

Receptacle panelboards should have minimum of six 20-amp 1-pole spare circuit breakers. For initial planning purposes, the number of receptacle circuits may be estimated by assuming 19 m^2 (200 square feet) per circuit.

All panelboards must be located in closets. In circumstances where horizontal runs would become excessive and another riser is not warranted, shallow closets, at least 600 mm (24inches) deep, may be used for additional panelboards.

Panelboards Serving Electronic Equipment. Electronic equipment panelboards serving personal computers, computer terminals or dedicated work stations should have an isolated ground bus. The service to the electronic panelboard should be supplied from an isolation transformer. Consideration shall be given to providing equipment with 200 percent neutrals. For initial planning purposes, the number of receptacle circuits may be estimated by assuming 19 m^2 (200 square feet) per circuit.

Feeders and branch circuits serving electronic load panels should be provided with isolated ground conductors.

6.10 Wiring Devices

In GSA buildings, general wiring devices must be specification grade. Emergency receptacles must be red. Isolated grounding receptacles must be orange. Special purpose receptacles must be brown. The color of standard receptacles and switches should be coordinated with the architectural color scheme; for example, white, not ivory, devices should be used if walls are white or light gray.

Building standard receptacle must be duplex, specification grade NEMA 5-20R. Special purpose receptacles should be provided as required. Device plates should be plastic, colored to match the receptacles.

Placement of Receptacles

Corridors. Receptacles in corridors shall be located 15 m (50 feet) on center and 7.5 m (25 feet) from corridor ends.

Office Space. Receptacles for housekeeping shall be placed in exterior walls and walls around permanent cores or corridors. Except for these, placement of receptacles in walls should be avoided to the maximum extent possible. See Chapter 3: *Architectural and Interior Design, Building Planning, Planning Module, Floor-to-Floor Heights* and *Vertical Building Zoning, and Space Planning, Office Space, Utility Placement.*

Raised Access Floor. All wiring beneath a raised access floor shall be routed in metal conduit or cable to underfloor distribution boxes. One distribution box per bay is recommended (see section *Placing Electrical Systems in Buildings, Horizontal Distribution of Power and Communications*, Figure 6-2 of this chapter). Flush-mounted access floor service boxes should be attached to the underfloor distribution boxes by means of a plug-in modular wiring system to facilitate easy relocation.

Number of Receptacles. For initial planning purposes, assume that office space uses systems furniture with a density of two work stations for every 9 m^2 (100 square feet). Electrical systems should be designed to allow two duplex outlets for electronic equipment power and two duplex outlets for normal power per work station.

Conference Rooms. Conference rooms shall be served in the same fashion as general office space.

Maintenance Shops. Maintenance shops require plugmold strips above work benches with outlets 450 mm (18 inches) on center.

Electrical and Communications Closets. Electrical closets require one emergency power receptacle. The communications closet will contain power and grounding for the passive and active devices used for the telecommunications system, including at least two dedicated 20A, 120 Volt duplex electrical outlets on emergency power, and additional convenience outlets at 1.8m (6 foot) intervals around the walls and direct connection to the main building grounding system. If uninterruptible power is required in communications closets, it will be furnished as part of the communications system.

Main Mechanical and Electrical Rooms. Main mechanical and electrical equipment rooms shall each have one emergency power receptacle.

Exterior Mechanical Equipment. Provide one receptacle adjacent to mechanical equipment exterior to the building.

Toilet Rooms. Each toilet room shall have one GFI receptacle at the vanity or sink.

6.11 Emergency Power Systems

All facilities must have an emergency power system for life safety as required by code. It must be designed in accordance with NFPA 110, *Emergency and Standby Power Systems*. See Chapter 7 for additional requirements.

Batteries

Self contained battery units may be used for individual light fixtures in buildings where an emergency generator is not required for other systems.

Fire alarm and security systems must be provided with their own battery back-up.

Generator Systems

The system should consist of a central engine generator and a separate distribution system with automatic transfer switch(es), distribution panels, and 480/277V lighting panel (if applicable) with dry-type transformers feeding 208/120V panels as required.

Service Conditions. If the unit is to be installed outdoors, it should be provided with a suitable enclosure and have provisions to ensure reliable starting in cold weather. Starting aids such as jacket-water heaters can be specified to improve reliable starting capability in cold weather.

When installed at high altitudes or in higher-than-rated ambient temperatures, the unit must be derated in accordance with manufacturers' recommendations. Operation of starting batteries and battery chargers must also be considered in sizing calculations. In humid locations heaters can reduce moisture collection in the generator windings. Silencers are required for all generators. Acoustical treatment of the generator room shall be provided if necessary.

Generators should be located at least 30 m (100 feet) from communications frame equipment to avoid radio frequency interference. See Chapter 3: *Architectural and Interior Design, Space Planning, Building Support Spaces, Mechanical and Electrical Rooms, Emergency Generator Rooms* for additional generator room requirements.

Radiators should be unit-mounted if possible. If ventilation is restricted in indoor applications, remote installation is acceptable. Heat recovery and load shedding should not be considered.

Capacity. The engine generator should be sized to approximately 110 percent of design load; ideally it should run at 50 percent to 80 percent of its rated capacity after the effect of the inrush current declines. When sizing the generator, consider the inrush current of the motors that are automatically started simultaneously. The initial voltage drop on generator output due to starting currents of loads must not exceed 15 percent.

Emergency Power Loads. Emergency power should be provided for the following functions:

- Egress and exit lighting.
- Fire alarm system.
- Generator auxiliaries.
- Smoke control systems (if required by code)[1].
- Fire pump.
- Lighting[2].
- Telephone switch.
- Security systems.
- Mechanical control systems.
- Building Automation System.
- Elevators (one per bank)[1].
- Sump pumps.
- Sewage ejector pumps.
- Exhaust fans removing toxic, explosive or flammable fumes.
- Uninterruptible power systems serving computer rooms[1].
- Air conditioning systems for computer and UPS rooms[1].
- Exhaust fan in UPS battery rooms.
- Power and lighting for Fire Control Center and Security Control Center.
- Lighting for main electrical room, electrical closets, and communications closets.
- Air conditioning systems serving communications closets.

Notes:

1 Evaluate on a case by case basis.

2 As noted in the Section: *Lighting Criteria for Building Spaces* of this chapter.

Distribution System. The distribution system should be designed so that emergency and auxiliary power sources cannot backfeed energy into the de-energized normal voltage systems under normal, emergency or failure conditions.

Generator Derangement Alarms. Generator derangement alarms must be provided in the generator room. All malfunctions should be transmitted to the BAS. In buildings without BAS, a generator alarm annunciator should be located next to the fire alarm panel.

Automatic Transfer Switches. Automatic transfer switches serving motor loads should be dual motor-operated (adjustable time delay neutral position) or have in-phase monitor (transfer when normal and emergency voltages are in phase) to reduce possible motor damage caused by out-of-phase transfer. They may also have pre-transfer contacts to signal time delay relays in the emergency motor control centers.

In order to reduce possible nuisance tripping of ground fault relays, automatic transfer switches serving 3-phase, 4-wire loads should have 4-pole contacts with an overlapping neutral.

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

Load Bank. Generally, generators should be run with the actual load connected. In selected applications where critical loads cannot tolerate a momentary outage, load banks may be considered.

Paralleling. For computer centers and other critical facilities, generator paralleling should be considered.

Fuel Distribution System. See Chapter 5: *Mechanical Engineering, Heating Systems, Boilers and Heat Exchangers*, for information on fuel oil piping and underground fuel oil tanks.

6.12 Uninterruptible Power Systems

In some facilities computer room back-up systems may be designed by the tenant agency. If this is the case, shell space and utility rough-ins should be provided. In facilities where uninterruptible power supply (UPS) systems are to be provided as part of the building construction, they should be designed as described in this section. All UPS systems are considered to be above standard for GSA space.

Requirements for UPS systems must be evaluated on a case by case basis. If UPS is required, it may or may not require generator back-up. When generator back-up is unnecessary, sufficient battery capacity should be provided to allow for an orderly shut-down.

Electrical Service Size. A UPS system should be sized with 25 percent spare capacity.

Critical Technical Loads. The nature, size, and locations of critical loads to be supplied by the UPS will be provided in the program. The UPS system should serve critical loads only. Non-critical loads should be served by separate distribution systems supplied from either the normal or electronic distribution system. Section *Site Distribution, Secondary Distribution, Secondary Distribution Systems* Figure 6-6 of this chapter shows the integration of UPS into the building power distribution system.

Emergency Electrical Power Source Requirements. When the UPS is running on emergency power, the current to recharge the UPS batteries should be limited. This limited battery charging load should be added when sizing the emergency generator.

If the UPS system is backed up by a generator to provide for continuous operation, then the generator must also provide power to all necessary auxiliary equipment, i.e., the lighting, ventilation, and air conditioning supplying the UPS and serving the critical technical area.

System Status and Control Panel. The UPS should include all instruments and controls for proper system operation. The system status panel should have an appropriate audio/visual alarm to alert operators of potential problems. It should include the following monitoring and alarm functions: system on, system bypassed, system fault, out of phase utility fault, closed generator circuit breaker. It should have an audible alarm and alarm silencer button. Since UPS equipment rooms are usually unattended, an additional remote system status panel must be provided in the space served by the UPS. The alarms should also be transmitted to the BAS.

UPS and Battery Room Requirements. Design the battery room in accordance with Article 480 of *National Electrical Code*. Provide emergency lighting in both spaces. Provide a telephone in or adjacent to the UPS room. Battery room design must accommodate: proper ventilation; hydrogen detection, spill containment; working clearances. See Chapter 3: *Architectural and Interior Design, Space Planning, Spaces for Uninterruptible Power Systems (UPS) and Batteries* for additional requirements for UPS and battery room. See Chapter 7 for additional requirements.

6.13 Computer Center Power Distribution

In some GSA buildings the power distribution system for computer centers will be designed by the tenant agency. In that case utility rough-in should be provided under the construction contract. If distribution is to be provided under the building contract, it should be designed according to the criteria in this section. Computer center power systems must comply with the Federal Information Processing Standard FIPS 94: *Guidelines on Electrical Power for ADP Installations*.

Power Distribution Units (PDU's). PDU's with internal or remote isolation transformers and output panelboards should be provided in all computer centers.

Non-linear Loads. Non-linear loads generate harmonic currents that are reflected into the neutral service conductors. Engineers should exercise caution when designing circuits and selecting equipment to serve non-linear loads, such as automated data processing equipment in computer centers. It is recommended to size neutrals at twice the size of the phase conductor. PDU's with internal or remote isolation transformers should also be derated for non-linear loads. The transformer rating must take the increased neutral size into account.

Computer Center Grounding. To prevent electrical noise from affecting computer system operation, a low-frequency power system grounding and a high-frequency signal reference grounding system should be provided. The design of the computer room grounding system should be discussed with the computer center staff.

Low Frequency Power System Grounding. The primary concern is to provide a safe, low-frequency, single point grounding system which complies with Article 250 of the *National Electrical Code*. The single point ground must be established to ground the isolation transformer or its associated main service distribution panel.

A grounding conductor should be run from the PDU isolation transformer to the nearest effective earth grounding electrode as defined in Article 250 of the NEC. All circuits serving Automated Data Processing (ADP) equipment from a PDU should have grounding conductors equal in size to the phase conductors.

High Frequency Power System Grounding. In addition to the low frequency power system grounding, a high frequency signal reference grounding system for radio frequency noise is required (with the two systems bonded together at one point). A grid made up of 600 mm (2 foot) squares will provide an effective signal reference grounding system. The raised floor grid may be used if it has mechanically bolted stringers. Alternatively a grid can be constructed by laying a 600 mm mesh (2-foot squares) of braided copper strap or 1.3 mm (16 gauge, 0.051 inch) by 50 mm (2-inch) copper strip directly on the structural floor below the raised access floor. Data processing equipment should be connected to the reference grid by the most direct route with a braided copper strap.

Common Mode Noise Reduction. The reduction of common mode noise is particularly important for the proper operation of computer-based, distributed microprocessor-based systems, i.e., building automation systems, electronic security systems, card access control systems, and local area networks.

The following guidelines should be considered to reduce common mode noise:

- Avoid running unshielded metallic signal or data lines parallel to power feeders.
- Where metallic signal or data lines must be routed in noise prone environments, use shielded cables or install wiring in ferrous metal conduit or enclosed cable trays.
- Locate metallic signal or data lines and equipment at a safe distance from arc- producing equipment such as line voltage regulators, transformers, battery chargers, motors, generators, and switching devices.
- Provide isolation transformers, electronic power distribution panelboards or power conditioners to serve critical electronics equipment loads.
- Provide isolated grounding service on dedicated circuits to critical data terminating or communicating equipment.
- Replace metallic data and signal conductors with fiber optic cables where practical.

Emergency Power Off (EPO) Systems. EPO pushbuttons should be provided in data processing centers at exits and at PDU's. Upon activation of push button or local fire alarm system, all power to the room and to the HVAC system for the room should be disconnected per *National Electric Code*, Article 645 and NFPA 75.

6.14 Lighting

Lighting should be designed to enhance both the overall building architecture as well as the effect of individual spaces within the building.

Interior Lighting

Consideration should be given to the options offered by direct lighting, indirect lighting, downlighting, uplighting and lighting from wall- or floor-mounted fixtures.

Illumination Levels. For lighting levels for interior spaces see the values indicated in Table 6-2. For those areas not listed in the table, the IES *Lighting Handbook* may be used as a guide.

In office areas with system furniture, assume that undercabinet task lighting is used and provide general illumination of about 300 Lux (30 footcandles) on the work surface. Ceiling lighting branch circuit capacity, however, should be sufficient to provide levels in Table 6-2 for occupancy changes.

Energy Efficient Design. Lighting design must comply with ASHRAE/IES 90.1 as modified by Table 6-3. Power allowances for normal system receptacles include task lighting as shown in Table 6-1. Lighting calculations should show the effect of both general and task lighting assuming that task lighting where it is used has compact fluorescent tubes.

Accessibility for Servicing. Careful consideration must be taken in the design of lighting systems regarding servicing of the fixtures and replacement of tubes or bulbs. This issue needs to be discussed with building operation staff to determine the dimensional limits of servicing equipment.

Light Sources. Generally, interior lighting should be fluorescent. Downlights should be compact fluorescent; high bay lighting should be high intensity discharge (HID) type. HID can also be an appropriate source for indirect lighting of high spaces. However, it should not be used in spaces where instantaneous control is important, such as conference rooms, auditoria or courtrooms.

Dimming can be accomplished with incandescent, fluorescent or HID fixtures, although HID and fluorescent dimmers should not be used where harmonics constitute a problem. Incandescent lighting should be used sparingly. It is appropriate where special architectural effects are desired.

General Lighting Fixture Criteria

Lighting Fixture Features. Lighting fixtures and associated fittings should always be of standard commercial design. Custom-designed fixtures should be avoided. They may only be used with express approval from GSA in cases where available standard units cannot fulfill the required function.

Offices and other areas using personal computers or other VDT systems should use indirect or deep-cell parabolic ceiling fixtures. If acrylic lenses or diffusers are used, they should be non-combustible.

Baseline Building Fixture. The fixture to be used for baseline cost comparisons for office space is a 600 mm (2-foot) by 1200 mm (4-foot) 3 lamp fixture utilizing T-8 or CFL lamps and electronic ballasts, deep cell parabolic diffuser, and white enamel reflector.

The number of fixture types and lamp types in the building must be minimized.

Table 6-2
Interior Illumination Levels (Average)

Area	Nominal Illumination Level in Lumens/Square Meter (lux)
Office Space	
Normal work station space, open or closed offices[1]	500
ADP Areas	500
Conference Rooms	300
Training Rooms	500
Internal Corridors	200
Auditoria	150-200
Public Areas	
Entrance Lobbies, Atria	200
Elevator Lobbies, Public Corridors	200
Ped. Tunnels and Bridges	200
Stairwells	200
Support Spaces	
Toilets	200
Staff Locker Rooms	200
Storage Rooms, Janitors' Closets	200
Electrical Rooms, Generator Rooms	200
Mechanical Rooms	200
Communications Rooms	200
Maintenance Shops	200
Loading Docks	200
Trash Rooms	200
Specialty Areas	
Dining Areas	150-200
Kitchens	500
Outleased Space	500
Physical Fitness Space	500
Child Care Centers	500
Structured Parking, General Space	50
Structured Parking, Intersections	100
Structured Parking, Entrances	500

[1] Level assumes a combination of task and ceiling lighting where systems furniture is used. (This may include a combination of direct/indirect fixtures at the ceiling for ambient lighting.)

NOTE: To determine footcandles (fc), divide lux amount by 11.

Table 6-3
System Performance Unit Lighting Power Allowance Common Activity Areas

UPD Area/Activity	UPD W/m²	Wft²	Note
Auditoriums	15.0	1.4	c
Corridor	8.6	0.8	a
Classroom/Lecture Hall	19.4	1.8	
Elect/Mech Equipment Room			
General	7.5	0.7	a
Control Rooms	16.1	1.5	a
Food Service			
Fast Food/Cafeteria	8.6	0.8	
Leisure Dining	15.0	1.4	b
Bar/Lounge	14.0	1.3	b
Kitchen	15.0	1.4	
Recreation/Lounge	5.4	0.5	
Stairs			
Active Traffic	6.5	0.6	
Emergency Exit	4.3	0.4	
Toilet & Washroom	5.4	0.5	
Garage			
Auto & Pedestrian Circulation	2.7	0.25	
Parking Area	2.1	0.2	
Laboratories	23.7	2.2	
Library			
Audio Visual	11.8	1.1	
Stack Area	16.1	1.5	
Card File & Cataloging	8.6	0.8	
Reading Area	10.7	1.0	
Lobby (General)			
Reception & Waiting	5.9	0.55	
Elevator Lobbies	4.3	0.4	
Atrium (Multi-Story)			
First 3 Floors	4.3	0.4	
Each Additional Floor	1.6	0.15	
Locker Room & Shower	6.5	0.6	

UPD Area/Activity	UPD W/m^2	Wft^2	Note
Office			
Enclosed offices of less than 900 ft^2 and all open plan offices without partitions or with partitions lower than 4.5 ft. below ceiling			
Reading, Typing and Filing	14.0	1.3	d
Drafting	23.6	2.2	d
Accounting	19.4	1.8	d
Open plan offices, 900ft^2 or larger, with medium partitions 3.5 to 4.5 ft. below ceiling			
Reading, Typing and Filing	16.1	1.5	a
Drafting	28.0	2.6	a
Accounting	22.6	2.1	a
Open plan offices, 900ft^2 or larger, with large partitions higher than 3.5 ft. below ceiling			
Reading, Typing and Filing	18.3	1.7	a
Drafting	32.3	3.0	a
Accounting	25.8	2.4	a
Common Activity Areas			
Conference/Meeting Room	14.0	1.3	c
Computer/Office Equipment	22.6	2.1	
Filing, Inactive	10.7	1.0	
Mail Room	19.4	1.8	
Shop (Non-Industrial)			
Machinery	26.9	2.5	
Electrical/Electronic	26.9	2.5	
Painting	17.2	1.6	
Carpentry	24.7	2.3	
Welding	12.9	1.2	
Storage and Warehouse			
Inactive Storage	2.1	0.2	
Active Storage, Bulky	3.2	0.3	
Active Storage, Fine	9.7	0.9	
Material Handling	10.7	1.0	
Unlisted Spaces	2.1	0.2	

Notes:

a Area factor of 1.0 shall be used for these spaces.

b Base UPD includes lighting required for clean-up purpose.

c A 1.5 adjustment factor is applicable for multi-function spaces.

d Minimum of 90% of all work stations shall be enclosed with partitions of the height prescribed.

Fixture Ballasts. Ballasts should have a sound rating of "A" for 430 MA lamps, "B" for 800 MA lamps and "C" for 1500 MA lamps. Electronic ballasts should be used wherever possible.

Exit Signs. Exit signs shall be of the LED type and meet the requirements of NFPA 101.

Lighting Criteria for Building Spaces

Office Lighting. Office lighting is generally fluorescent lighting. A lighting layout with a fairly even level of general illumination is desirable. Modular (plug-in) wiring for fluorescent lighting fixtures should be used for office areas to facilitate changes. In open office areas with systems furniture partitions, the coefficient of utilization must be reduced to account for the light obstruction and absorption of the partitions.

Design for glare, contrast, visual comfort and color rendering and correction must be in compliance with recommendations contained in the Illuminating Engineering Society of North America (IES) *Lighting Handbook*.

Task lighting will be used in situations, such as areas of systems furniture, where the general lighting level would be insufficient for the specific functions required.

ADP Areas. Generally, ADP areas should have the same lighting as offices. If the area contains special work stations for computer graphics, dimmable fluorescent lighting may be required. If a large ADP area is segregated into areas of high and low personnel activity, switching design should provide for separate control of lights in high- and low-activity areas of the space.

Conference Rooms and Training Rooms. These spaces should have a combination of fluorescent and dimmable incandescent lighting.

Lobbies, Atria, Tunnels and Public Corridors

Special lighting design concepts are encouraged in these spaces. The lighting design should be an integral part of the architecture. Wall fixtures or combination wall and ceiling fixtures may be considered in corridors and tunnels to help break the monotony of a long, plain space. As stated previously, careful consideration must be taken in the design of lighting systems regarding servicing of fixtures and replacement of lamps.

Mechanical and Electrical Spaces

Lighting in equipment rooms or closets needs to be provided by industrial-type fluorescent fixtures. Care should be taken to locate light fixtures so that lighting is not obstructed by tall or suspended pieces of equipment.

Dining Areas and Serveries

Ample daylight is the illumination of choice in dining areas, assisted by fluorescent fixtures. Limited compact fluorescent lighting for accents is acceptable if comparable architectural effect to incandescent lighting can be achieved.

Character-Defining Spaces in Historic Structures. Spaces that contribute to the character of a historic structure, as identified the HBPP, should be lighted in a manner that enhances their historic and architectural character. Maintenance and rehabilitation of historic lighting fixtures should be considered, and may be required in the HBPP. Care should be taken to avoid placing fixtures, switches, conduit, or other electrical facilities through character-defining architectural elements.

Structured Parking. Fixtures for parking areas may be fluorescent strip fixtures with wire guards or diffusers. Care must be taken in locating fixtures to maintain the required vehicle clearance. Enclosed fluorescent or HID fixtures should be considered for above-grade parking structures.

High Bay Lighting... Lighting in shop, supply, or warehouse areas with ceilings above 4900 mm (16 feet) should be color-improved high-pressure sodium. In areas where color rendition is known to be of particular importance, metal halide should be used.

Supplemental Emergency Lighting. Partial emergency powered lighting must also be provided in main mechanical, electrical and communications equipment rooms; UPS, battery and ADP rooms; security control centers; fire control centers; the room where the Building Automation System is located; adjacent to exits; and stairwells. Where CCTV cameras are used for security systems, emergency lighting should be provided at the task area.

Lighting Controls

All lighting must be provided with manual, automatic, or programmable microprocessor lighting controls. The application of these controls and the controlled zones will depend on a number of space factors: frequency of use, available daylighting, normal and extended work hours and the use of open or closed office plans. All of these factors must be considered when establishing zones, zone controls and appropriate lighting control.

Lighting Configuration Benefits. An appropriate lighting configuration can benefit the Government; it reduces operating costs by permitting limited operation after working hours, takes advantage of natural light during the daytime working hours and facilitates the subdivision of spaces.

Enclosed Space Lighting Controls. Enclosed space lighting controls may include switches, occupancy sensors, daylight sensors, light level sensors or micro-processors. The lights can be zoned by space or multiple spaces. If microprocessor controls are used to turn off the lights, a local means of override should be provided in every office to continue operations when required.

The following design guidance is provided for enclosed areas:

- Photoelectric sensors that reduce lighting levels in response to daylighting are recommended for small closed spaces with glazing.
- Occupancy sensors should be considered for small closed spaces without glazing.
- Microprocessor control, programmable controller or central computer control are recommended for multiple closed spaces or large zones.
- Touchtone telephone or manual override controls should be provided if microprocessor, programmable controller or central computer control is provided.

Open Space Lighting Controls. Open space lighting controls may include switches, light level sensors for spaces adjacent to glazing and microprocessor controls for zones within the space. If microprocessor controls are used to turn off the lights, a local means of override should be provided to continue operations when required.

Large open space should be subdivided into zones of approximately 100 m^2 (1,000 square feet) or one bay. The following guidelines are provided for open plan spaces:

- Controls should be located on core area walls, on permanent corridor walls or on columns
- Remote control schemes and reductions from a programmable controller, microprocessor, and/or central computer should be considered.

Occupancy Sensor Lighting Controls. Infrared, ultrasonic, or passive dual sensors should be considered for small, enclosed office spaces, corridors (if adequate lighting is provided by emergency system) and toilet areas. Each occupancy sensor should control no more than one enclosed space/area. Each occupancy sensor should be marked by a label identifying the panel and circuit number. Occupancy sensors should not be used in open office areas or spaces housing heat producing equipment.

Ambient Light Sensor Controls. Photoelectric sensors should be considered for fixtures adjacent to glazed areas and for parking structures.

Exterior Lighting

Exterior luminaires must comply with local zoning laws. Lighting levels for exterior spaces should be the values indicated by the IES Lighting Handbook. Flood lighting should only be provided if specified in the building program. Exterior lighting of a historic structure should be designed to blend with and support the new architectural characteristics that contribute to the structure's character.

Parking and Roadway Lighting. Parking and roadway lighting should be an HID source and should not exceed a 10 to 1 maximum to minimum ratio and a 4 to 1 average to minimum ratio.

Parking lots should be designed with high-efficiency, pole-mounted luminaires. High- pressure sodium lamps are preferred but consideration should be given to existing site illumination and the local environment. Emergency power is not required for parking lot lighting.

Entrances. Lighting fixtures should be provided at all entrances and exits of major structures.

Loading Docks. Exterior door lighting should be provided at loading docks. Fixtures for illumination of the interior of trailers should be provided at each truck position.

Controls. Exterior lighting circuits should be controlled by photocell and a time clock controller to include both all-night and part-night lighting circuits.

U.S. Custom House, New Orleans, LA

6.15 Raceway System for Communications

Communications systems for all GSA buildings will meet the requirements of FIBS Standard 175: *Federal Building Standard for Telecommunications Pathways and Spaces.* Communications systems for all GSA buildings will be designed by FTS and installed by FTS or the tenant. Only the raceway system is part of the building design and construction. It consists of manholes, ductbanks, entrance rooms and vaults, communications equipment room(s), closets, and the sleeves, ducts, conduits, raceways and outlets that comprise the horizontal pathways, backbone pathways and workstation outlets of the technology infrastructure.

Bonding for communication system must comply Federal Information Processing Standard 195: *Federal Building Grounding and Bonding Requirements for Telecommunications* (see also EIA/TIA Standard 607 and related bulletins).

Since FTS will manage the design of the communications systems, all criteria for routing and types of raceways must be obtained from FTS.

Communications Equipment or Frame Room. A communications equipment or frame room should be provided in every building. It must be sized to accommodate voice and data distribution and transmission equipment and support equipment with adequate equipment access clearances. FTS will provide detailed information on the communications equipment. A 5 ohm (maximum) signal ground and an emergency power receptacle should be provided in the room. The electrical service should be sized to accommodate the largest commercial switch of the type designated by FTS. The room should be shielded from radio and noise interferences. (See Chapter 3: *Architectural and Interior Design, Space Planning, Mechanical and Electrical Rooms* for additional information on frame room requirements.)

Communications Closets. Communications closets shall meet the requirements of FIBS Standard 175: *Federal Building Standard for Telecommunications Pathways and Spaces*. See Chapter 3: *Architectural and Interior Design, Communications Closets* for additional information on communications closets. Communications and electrical closets should be located adjacent to each other. Communications closets must be stacked vertically. Communications closets should be sized to accommodate telephone terminal boards and broadband and narrow-band data communications equipment, including cross-connects, lightwave terminal cabinets, and equipment racks with patch panels and concentrators. Telecommunications closets will contain the mechanical terminations for that portion of the horizontal wiring system and portion of the backbone wiring system for the building area served by the closet. It may also contain the main or intermediate cross-connect for the backbone wiring system. The telecommunications closet may also provide the demarcation point or interbuilding entrance facility. Closets will have the capability for continuous HVAC service, and be equipped with fire protection per Chapter 7.

Communications Raceways

Raised Access Floor. The standard option for delivering communications services in Federal buildings is by laying the cable in a tray for main runs and then branching directly on the floor slab below the raised access flooring system. See section on *Placing Electrical Systems in Buildings, Horizontal Distribution of Power and Communications* in this chapter.

Above Ceiling Delivery. Communications distribution in ceilings should be avoided and only used where no other alternative exists. Where necessary, communications cabling above ceilings must be run in cable tray and/or conduit.

Communications Outlets. Telephone and data outlets are to be located by FTS; layout information will be provided to A/E's.

Administration of Communications Infrastructure. Long-term use of the communications infrastructure requires administration of the systems including placing identification on all elements, keeping records and drawings on all elements, and task order information on work performed on all infrastructure elements. The administration system must maintain information on horizontal and backbone pathways, equipment rooms and closet spaces, cables, termination hardware, termination positions, splices, grounding system and bonding conductors. The information should be compatible with other building management and facility maintenance systems employed at the site.

6.16 Layout of Main Electrical Rooms

Separate electrical rooms may be provided for medium voltage and low voltage switchgear assemblies.

Vertical Clearances. Main electrical equipment rooms generally should have a clear height to the underside of the structure for compliance with requirements of the NEC. Where maintenance or equipment replacement requires the lifting of heavy parts, hoists should be installed.

Horizontal Clearances. Electrical equipment rooms should be planned with clear circulation aisles and adequate access to all equipment. Layout should be neat, and the equipment rooms should be easy to clean. Horizontal clearances should comply with requirements set forth by the NEC.

Lighting. Lighting in equipment rooms should be laid out so as not to interfere with equipment. Switched emergency lighting must be provided in main electrical rooms.

Housekeeping Pads. Housekeeping pads should be at least 75 mm (3 inches) larger than the mounted equipment on all sides.

Operation and Maintenance Manuals. Documentation on all building systems should be provided for the guidance of the building engineering staff. This should show the actual elements that have been installed, how they performed during testing, and how they operate as a system in the completed facility.

The building staff should be provided with the following:

- Record drawings and specifications.
- Operating manuals with a schematic diagram, sequence of operation and system operating criteria for each system installed.
- Maintenance manuals with complete information for all major components in the facility.

Posted Instructions. Posted operating instructions are required for manually operated electrical systems. They should consist of simplified instructions and diagrams of equipment, controls and operation of the systems, including selector switches, main-tie-main transfers, ATS by-pass, UPS by-pass, etc.

Instructions should be framed and posted adjacent to the major equipment of the system.

6.17 Alterations in Existing Buildings and Historic Structures

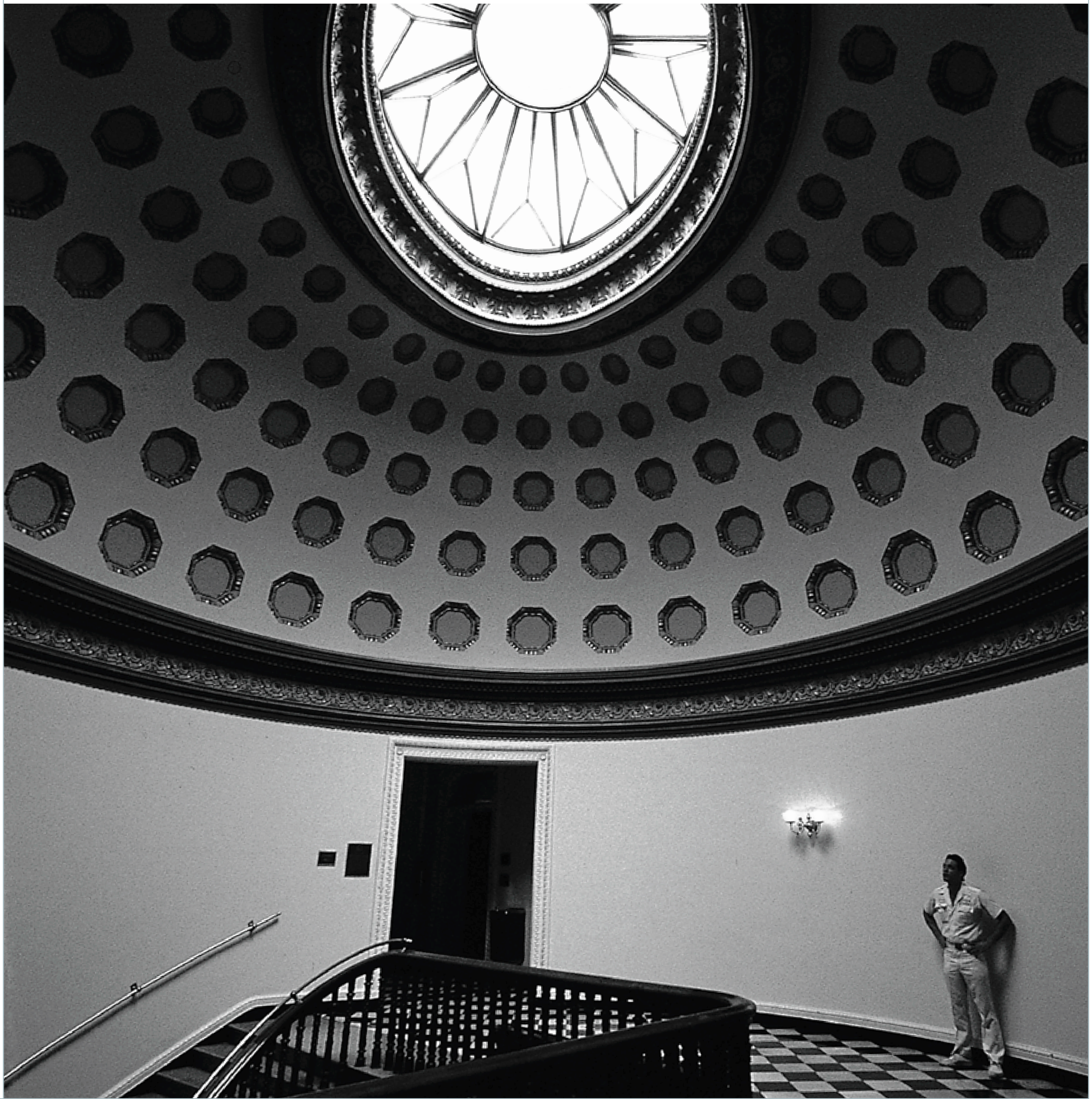
The goal of GSA's alteration projects is to approximate as well as possible the facilities standards described in this book for new projects. Renovation designs must satisfy the immediate occupancy needs but should also anticipate additional future changes. Remodeling should make building systems more flexible.

Alteration projects can occur at three basic scales: refurbishing 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 new requirements within the parameters and constraints of the existing systems. The smaller the area in comparison to the overall building, the less changes to existing systems should be attempted.

In the second case, the engineer has the opportunity to design major upgrades into the electrical and communications systems. The electrical and communications 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 Building Preservation Plan (BPP) which identifies zones of architectural importance, specific character-defining elements that should be preserved, and



standards to be employed. See Chapter 1: *General Requirements, Applicability of the Facilities Standards, Types of Facilities, Historic Buildings.*

The electrical systems in historic buildings often differ greatly from today's design and construction standards, and frequently these systems need to be upgraded substantially or completely rebuilt or replaced. The end result should be a building whose lighting and other electrical facilities support its modern use while retaining its historic and architectural character. Historic light fixtures, hardware and other period features should be retained and any supplementation shall be inconspicuous to avoid detracting from existing historic building ornamental spaces.

The end user requirements are an important part of the programming information for alteration projects. Close interaction between designers and users is essential during the programming and conceptual design phase to meet the users' needs without excessive construction costs. The general policies and standards that an administrator would give designers are usually not specific enough.

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

See Chapter 3: *Architectural and Interior Design, Alterations in Existing Buildings and Historic Structures.*

Placing Electrical and Communications Systems in Renovated Buildings

Even more than in new construction, the optimal placement of engineering systems in the building structure is a crucial element in the success of the alteration. Vertical and horizontal distribution of utilities must be integrated into the architectural concept from the outset.

Chapter 3: *Architectural and Interior Design, Alterations in Existing Buildings and Historic Structures, Placing Mechanical and Electrical Systems in Renovated Buildings* describes some of the strategies available for placement of power, lighting and communications systems.

Vertical Distribution. If new risers are required, they should preferably be located in or adjacent to existing closets. Where there is lack of space, communications risers and electrical risers can perhaps be combined.

Horizontal Distribution. Raised access flooring is highly recommended for large modernization projects. Most of the criteria established for raised flooring earlier in this chapter would apply, except that module sizes may have to be varied to fit existing conditions.

In buildings where raised access flooring is not feasible, horizontal electrical and communications distribution may be located in the ceiling. Fortunately, many older buildings have high floor-to-floor heights, which permit an expansion of the existing ceiling space. Vertical zoning of this space between various engineering systems is critical. The zoning should be established according to the principles described earlier in this chapter or according to existing ceiling zones.

In buildings with decorative or inaccessible ceilings, electrical raceways for power and communications lines can be located along walls, or be incorporated into the design of a molding or a special chase between window sills and floor. Raceways should have some additional space for future changes to the electrical and communications systems.

In buildings with fairly close spacing of columns or masonry walls, it may be possible to locate all receptacles, phone and data outlets in furred wall space. The furring should be treated as an architectural feature in historic buildings. If bay sizes are too large for this solution, systems furniture with built-in electrical service is an alternative. Power poles are also an option as long as they are integrated into the architectural design. Poke-through and flat cable should be avoided.

Building Service

If new switchgear is provided, consider sizing it according to the loads provided in the section *Electrical Load Analysis*, Table 6-1, of this chapter even if less than the entire building is being remodeled at the time.

Secondary Power Distribution

New panelboards should be added as required with ample spare capacity. See section *Electrical Load Analysis, Standards for Sizing Equipment and Systems* in this chapter. In both large and small remodeling projects, panelboards serving electronic loads should be served from an isolation transformer and sized with consideration given to harmonic currents.

Computer Center Power

Non-linear computer loads should be isolated from normal power. Ensure that the size of the supply transformer for non-linear loads is rated and protected on the basis of input and output current. Provide circuit breakers with true RMS overload protection on the supply and load sides of the transformer and increase the size of the neutral to twice the size of the phase conductor.

Lighting

General Renovations. For small remodeling projects, existing lighting systems should be matched for uniformity and ease of maintenance. In total building modernizations, the guidelines established in the section *Lighting* of this chapter should be followed.

In structures with ornamental or inaccessible ceilings, indirect lighting offers many possibilities. Fixtures may be located in wall coves or at the top of low columns or partitions.

Historic Structures. In historic buildings, the quality of the fixtures and the quality of the light are integral to the architectural integrity of the building. The character of many old buildings has been compromised by poor lighting designs. Designers are encouraged to seek imaginative solutions to achieve required light output while preserving the essential visual characteristics of historic lighting, such as variable light levels, highlighting of architectural features, light source color, reflected patterns, and the surface reflectivity of historic materials.

Many historic buildings have beautiful plaster ceilings that do not permit use of lay-in fixtures. Indirect lighting from coves, combined with task lighting, can be a good alternative. Wall sconces are another alternative, particularly in corridors. In public spaces, chandeliers or other decorative fixtures may need to be restored or duplicated.

These fixtures may be retro-fitted with compact fluorescent lamps, reflectors, and other light sources to increase light output and energy efficiency. Use of halide lamps as the sole light source in historic fixtures is discouraged because of differential color shifting that occurs as lamps age.

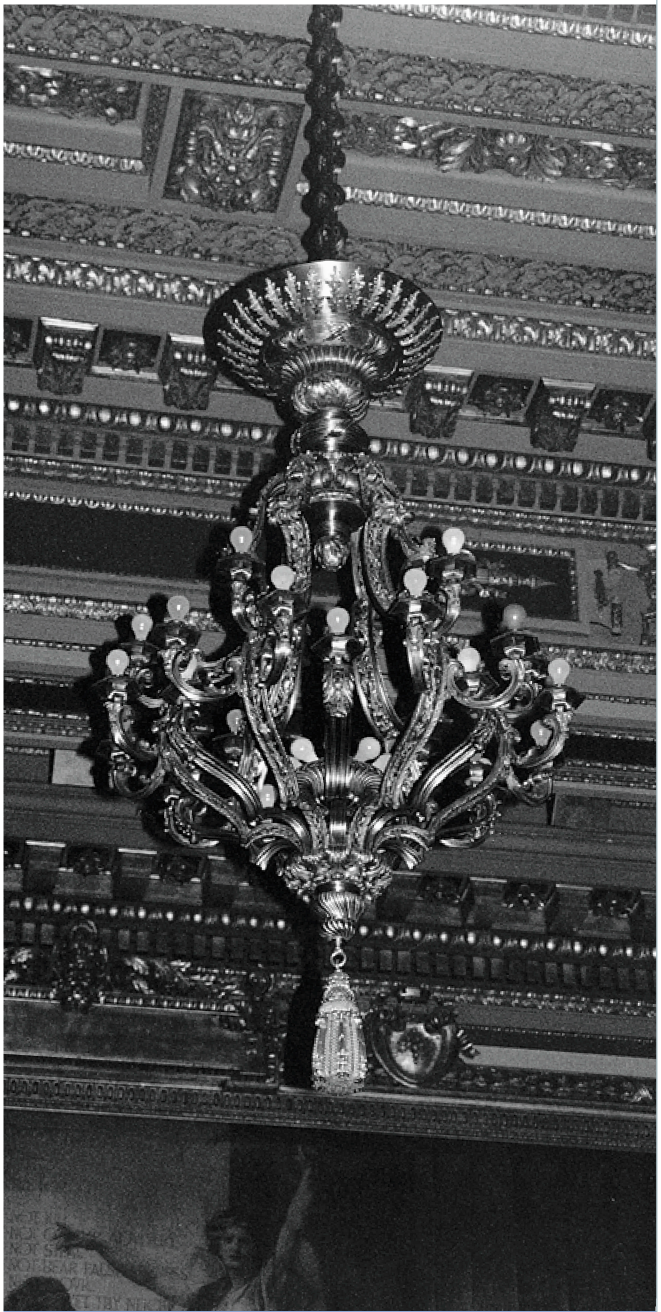
Reproduction historic lights for significant spaces such as courtrooms may be fitted with multiple light sources and separate switches to allow for multiple light levels. Select lamps providing color rendition as close as possible to that of original lighting. In historically significant spaces requiring increased light levels, apply the following order of preference:

1. Retrofit historic lights with energy efficient ballasts/lamps

2. Add discretely designed supplementary lighting, preferably reflected light, to avoid competing with period lighting.

In historically significant spaces, supplementing of ceiling-mounted lights with wall mounted sconces, indirect lights mounted on furniture, or freestanding lamps is preferable to installing additional ceiling mounted fixtures.

The light source is another important concern. Typically, the existing source is incandescent. Where feasible, the light fixture should be changed to a fluorescent source, with color rendition as close as possible to that of the incandescent light.



Metzenbaum Courthouse, Cleveland, OH

Communications Distribution

Communications systems are always designed by FTS, and they will, therefore, furnish raceway systems criteria for alteration projects.

Telephone. Generally, older buildings have telephone closets and wiring. For small alterations, the telephone system should probably just be extended to meet new requirements. For major building modernizations, a new distribution system for phone and data should be installed, as described in the section *Raceway System for Communications* of this chapter.

Data. Data wiring is generally non-existent in older buildings. An above-ceiling cable tray should be included in even the smallest projects to facilitate computer networking.

In total building renovations, vertical and horizontal data and telephone distribution should be provided. If there is no existing underfloor system, consider a cable tray loop in the ceiling of the permanent circulation corridors.