Every effort should be made to create a facility that protects the safety of its occupants as well as the community around it. This biomedical research facility is dedicated to the safe care of the patients and community it serves. Careful attention to safety should be incorporated in each aspect of the facility design, and the design should comply with safety codes and regulations as mandated by governing agencies. In stark contrast to laboratory facilities, hospital technical requirements are largely promulgated by code and regulatory agencies due to their legislative authority to ensure certain minimum standards of patient care.

A significant number of published hospital guidelines for technical requirements exist beyond those required by code. These guidelines are often adopted with certain administrative amendments to serve as state hospital and other licensure standards. Publication of the Public Health Services' Minimum Guidelines for Hospital Construction has been discontinued. The NIH uses the AIA Guidelines for Construction and Equipment of Hospitals and Medical Facilities and the Accreditation Manual for Hospitals to supplement requirements of other criteria.

Unlike laboratories, technical requirements for hospital mechanical, electrical, and plumbing systems, and noise control, etc., can vary on a room-by-room basis. Further, their stringency is often related to life support systems and equipment, making it difficult to separate technical and functional requirements. See room data sheets for room-by-room criteria.

Systems for hazardous materials handling shall be evaluated by a hazardous materials consultant and reviewed and approved by the NIH Division of Safety.

An infection control program should be developed with the NIH to safely handle and dispose of all infectious waste.

Refer to the Laboratory Research Design Policy and Guidelines, and the Reference Material, Sections on Health and Safety for requirements regarding chemicals. Where the use of chemicals is of a quantity and have specific hazardous properties, refer to the NFPA regulations.

As a result, many industry standards exceed minimum code requirements. The following is a listing of the code and the guidelines recommended for use:

- NFPA
- National Building Officials and Code Administrations, International (BOCA)
- National Electrical Code (NEC)
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)
- Washington Suburban Sanitary Commission (WSSC)
- UFAS
- Joint Commission for Accreditation of Health care Organizations (JCAHO)
- AIA, *Guidelines for Construction and Equipment of Hospital and Medical Facilities*
- AIA, *Guidelines for Construction and Equipment of Mental Health Facilities* (currently in draft format)
- Veterans Administration Health Facilities Planning Guidelines
- Department of Defense Health Facilities Guidelines (Army Corps of Engineers, Air Force Health Facilities Office, and Naval Facilities Engineering Command)
- Public Health Service Facilities Manual

D.1 Designing in the Existing Facility

Most PCUs are located on the south face of the central wings of the CCC. The public elevators are in the middle of the area, and service elevators are at the ends. The PCU corridor ("S"Corridor), which connects the public and service elevator lobbies, determines the "spine" of the PCU.

The few units which are located elsewhere in the facility are typically entered from the service elevator lobbies for both service and public traffic.

D.2 Architectural Finishes and Materials

D.2.1 Floors

Floors should accommodate different types of wheeled conveyances and be devoid of abrupt changes in elevation. Constant floor elevation should be maintained throughout for safety and ease of movement of wheeled equipment. Raised thresholds, steps, and ramps should be avoided. All expansion joint cover plates shall be flushed with the finished floor. Shower stall thresholds shall be flush or no higher than 12.5 mm.

All exposed concrete floors in facilities should be finished with sealers to protect against deterioration due to chemicals, oils, greases, salts, wear, and other factors. Floor finishes shall be as recommended in the room data sheets.

Waterproofing is required for wet spaces when located over occupied areas to protect ceilings below from water damage due to leakage from spilled liquids and cleaning solutions form, e.g., Operating rooms, dishwash and cartwash areas, decontamination and clean-up, tub rooms and whirlpool areas, laboratory glasswash rooms, sterilizer closets, toilets and showers, food preparation areas, autopsy rooms, and dental treatment rooms.

D.2.2 Walls

Performance of gypsum wallboard must satisfy criteria for fire rating, STC rating, flame spread, and thermal insulation. In areas subject to severe impact from mobile equipment, the use of durable wall materials such as masonry.

Wall partitions require additional reinforcement as called out in the NIH Guidelines and Policies manual for positive attachment of surface-mounted items such as casework, wall bumpers, toilet accessories, and other equipment. The Architect/Engineer should coordinate requirements with the Structural Engineer.

Height of partitions shall be as required by all applicable codes and regulations and as necessary to assure the acoustical privacy of patients, staff, and visitors to the NIH facility.

Protective barrier partitions shall be designed to protect occupants or equipment in rooms, spaces, and compartments from fire, smoke, and radiation exposure, or for physical security purposes. In accordance with the Interim Life Safety Provisions of the JCAHO Accreditation Manual and the guidance received from the Building Manager and Safety Officer. Reinforced masonry or concrete partitions are desirable around areas where the physical security of valuables or drugs is required. All bulk controlled-substance drug-storage-vault side walls shall be equivalent to concrete construction.

Finishes can be generally categorized into the same dry, wet, damp use, and protective classifications as interior substrate construction. Finishes may be directly applied to the partition systems or may be applied to a substrate which has been previously applied to the partition system. Finish materials, substrates, and the basic partition system must work compatibly to be effective. Finishes should be biologically safe, durable, soft in tone, and easily maintainable. A three-coat paint system should be used. One primer coat and two finish coats should be applied if the existing surface necessitates it. All paint used in the CCC must be low odor producing nontoxic materials. Latex acrylic enamel paints are permitted, however, the use of solvent based materials can only be permitted by the Building Manager the Safety Officer.

All nonproprietary paint colors shall be selected from a nationally recognized paint manufacturer. Colors shall be selected with regard to their effect on the function of the space. Color intensity is important, usually falling into a range of not too intense, not boring, not too exciting, calming yet pleasant, harmonious with other design elements, and supportive of the design goals. Selections vary and are based upon criteria such as patient type, mix (gender), age, and the specific requirements of the medical research program. The colors should be coordinated with the basic architectural finish schedule. See room data sheets for specific requirements.

Wall coverings shall be treated with mildew and antibacterial additives and meet the flame spread and stain resistance requirements of the applicable NFPA criteria and Federal Specifications.

Handrails and bumper guards are required on both sides of corridors with walls constructed of gypsum wallboard, veneer plaster, or plaster, in all nonadministration areas. This includes all nursing units, clinical and patient care areas, and dietetic and service areas. Materials and profile are to meet all handicapped, aesthetic, and functional requirements.

Bumper guards are required on both sides of corridors in high-use, service, and dietetic areas. Material and construction requirements are to meet anticipated equipment impact loads in these areas.

Corner guards are required to be continuous floor to ceiling and provided in all nonadministration areas. Material and profile are to meet all aesthetic and functional requirements.

It is recommended that the Architect/Engineer review specific finish requirements for room functions listed in the room data sheets. Where room types and finishes are not yet available, the NIH representative should be consulted for verification of room finish requirements.

D.2.3 Ceilings and Lighting Fixtures

Where appropriate, lay-in acoustical ceiling tile in public areas shall be 600 mm x 600 mm x 20 mm regular-edge (reveal-edge) tiles. Public areas are defined as lobbies, elevator lobbies, cafeterias, and corridors used by the general public, patient room corridors and other areas as determined by the NIH Division of Engineering Services, Facilities Engineering Branch. Maximum accessibility shall be provided in corridor ceilings to the mechanical and electrical distribution systems above. Concealed-spline ceiling systems requiring special tools to lower tile assembly shall not be used. Access panels into ceiling plenums shall be color coded with tabs to identify the type of utility present. When acoustic treatment is required in the presence of high levels of moisture, mylar-faced acoustic tiles shall be used. Unless otherwise stated, all ceiling tiles shall be the NIH standard.

Ceiling grid layout is to be symmetrical so that tiles and grid members retain modular dimensions. Modular coordination can decrease ceiling cost and provide dimensional continuity at

corridor intersections.

Ceiling height is to be no less than 2,400 mm throughout the facility. See the room data sheets, where the indicated heights are specified for various functions.
Lighting should be appropriate to the activity and situation. It should be patient controllable, where possible. The range should be for greater brightness at the high end but should not be harsh and should avoid glare. Where fluorescent lighting is used, the more natural, full-spectrum colors are preferred.

Lights are to be secured to the structure above.

D.2.4 Windows and Window Materials

Interior windows shall meet all requirements as defined in the Reference Materials.

The construction of window heads shall include a fireproof back plate or board designed to accommodate the attachment of window coverings that may be installed by the medical center after completion of construction.

All windows in MHPCUs, alcohol dependency treatment PCUs, drug abuse treatment PCUs, and medical, surgical, and nursing (MS&N) security bedrooms shall be glazed with laminated glass. Laminated glass shall be 10 mm thick in locked patient units and security rooms, and 8 mm thick elsewhere. Large expanses of glass may require thicker glass. Glass manufacturers should be consulted if this circumstance exists.

If laminated glass is required for double-glazed windows, it shall be provided for interior panes only, except in mental health and behavioral nursing units with sill/stools less than 2,000 mm above the ground and windows facing a courtyard. Where this occurs, a laminated-glass interior pane and tempered-glass exterior pane are required.

D.2.5 Doors

Doors shall be either solid-core wood or hollow-steel construction, be 45 mm thick, and meet fire code requirements. Dutch or half-

doors are unacceptable. Doors shall have nonremovable pins. Hollow-steel doors are not desirable in wet areas because of rust problems.

Vision panels should be provided in all doors where someone could be struck by a door opened suddenly from the opposite side. Specifically, all doors crossing corridors or enclosing stairways shall be provided with vision panels. Individual offices, laboratories, or spaces where privacy may be needed do not require vision panels but may have translucent glass panels to admit light without permitting vision. Doors to toilets, bedrooms, and examination rooms do not need vision panels. All vision panels in doors shall be located no more than 940 mm from the bottom edge of the door to the lower edge of the vision panel. The dimension from the latch edge of the door to the nearest edge of the vision panel shall be 230 mm (these measurements are to the visible glass edge and not to the edge of the opening which is cut in the door.) In the case where a vision panel is limited to 64,500 mm^2, a 100 mm by 645 mm window shall be used.

D.2.6 Door Hardware

The key system design shall be reviewed through the Division of Security of Operations, Crime Prevention Branch, Locksmith Unit. Such coordination is to be completed prior to submitting the hardware schedule to the Contracting Officer. The key and lock system shall be based on several levels of master keys. Grand masters and great-grand masters shall be provided for functional zones and modules. Master keys shall not be capable of opening pharmacy, computer areas, medicine stations, and control doors to Mental Health.

Room door-lock keys and day-lock combinations, where applicable, are special keys and shall not be mastered. Particular emphasis should be placed on determining hardware criteria for special areas such as Mental Health, etc.

Doors to the exterior of the building that are also used as part of a means of egress (exit) will be readily operable from the inside of the building. When security devices are to be provided on egress doors, they are normally designed to unlatch upon loss of power (fail-safe). In some buildings at the NIH, it is desirable to have the latching device to remain in place upon a power failure (fail-secure). In either case, the determination of whether the device will be fail-safe or fail-secure will be made by the NIH Division of Security Operations and the NIH Division of Safety, Fire Prevention Section, with input from the clinical staff.

Any plan or specification for each new or modified door shall be submitted to the following:

Division of Security Operations, Crime Prevention Branch
Room B3Bl6, Building 31
Phone (301) 496-9818

and:

Division of Safety, EMB Fire Prevention Section
Building 15G-2
Phone (301) 496-0487

Keys are to be turned over to the Project Officer, who will give them to the Locksmith Shop Unit.

D.3 Furniture and Equipment

D.3.1 Equipment, Fixed Equipment, Medical Equipment

The following are definitions of equipment by groupings:

Group 1: Contractor furnished, contractor installed
Group 2: Government furnished, contractor installed
Group 3: Government furnished, government installed
Group 4: Movable equipment and furnishings

Equipment shall be arranged and organized so as to provide adequate circulation, work flow, and maintenance clearances. Head clearance of 2,000 mm shall be maintained for all suspended equipment.

Surgical storage consoles, wall-mounted panels, and accessories in operating rooms shall be flush mounted for aseptic control.

Appropriate catalog cut sheets shall be provided for all items of equipment having a logistical category and code and for any items having unique utility requirements, structural support or space requirements. General Service Administration (GSA) catalogues shall be referred to for procurement wherever possible.

Floor depressions to accommodate cart washers, floor-loading sterilizers, radiographic equipment, electrical raceways and environmentally controlled room equipment, walk-in refrigerators, audiometric suites, computer rooms, high-density shelving, and any other appropriate space except in laboratory spaces where future flexibility is a requirement.

Wall-partitioning systems shall be adequately reinforced for toilet accessories, physical therapy equipment, radiographic equipment, hanging supply carts, and other items of wall-hung equipment. All fixed equipment shall be mounted to resist seismic forces in accordance with seismic levels.

The use of suspended ceiling surface for the direct support of intravenous infusion tracks or cubicle curtain tracks is not acceptable. Ceiling-mounted accessories secured through the ceiling to secondary support members are mandatory. Suspended

heavy equipment or equipment tracks shall be secured to independent structural assemblies attached directly to the structural floor and roof-framing members overhead. The Structural Engineer shall be consulted as appropriate.

Control of ventilation for the employee working environment must be provided in accordance with the latest edition of the Occupational Safety and Health Act (OSHA) of 1970.

Dust and debris collection shall be provided for locations where generated. Exterior air supply, exhaust with filtration, and dust containers must be provided.

The Architect/Engineer shall develop equipment specifications for all equipment that does not have current guide specifications. All equipment specifications should permit procurement of the latest model of equipment through GSA services where possible. All equipment specifications shall accommodate reputable vendors. Equipment specifications shall discuss the scope of services to be provided by mechanical and electrical contractors for installing Government-furnished equipment.

The use of an equipment consultant with knowledge of sterilizing equipment is recommended. Particular emphasis should be placed on the selection of ethylene oxide sterilizers due to codes and changing regulatory requirements.

Various models of dental radiographic units require different structural wall supports. When two or more units are installed in the same room, a single control unit shall be used when feasible.

D.3.2 Furnishings

Hospital furnishing selections should reflect current technological advances, especially in the area of ergonomics.

D.3.3 Casework

Casework design shall meet the functional, aesthetic, flexibility, and maintenance needs of each user. Casework should be selected to minimize maintenance requirements and equipment storage requirements. A modular system should be considered. The use

of standard hospital casework shall be evaluated with the NIH during the design phase. Flexible, modular, or suspended-construction casework systems may be used in projects deemed appropriate. Corrosion-resistant steel or other nonporous, seamless joint casework shall be installed in high use wet areas such as operating rooms and their substerile and cleanup areas and central sterile supply decontamination and cleanup areas. Special consideration must be given to the colors of countertops in laboratory areas and maintenance shops where there is a problem of staining from various solutions. All effort shall be made to use casework as defined by the GSA equipment schedule.

Anchorage of shelving and wall cabinets shall be in accordance with the Architectural and Structural Sections of the Reference Materials.

D.3.4 Window Treatments

Lightproof shades shall be provided on windows in electron microscopy rooms and fluorescent microscopy rooms and all other rooms where light transmission is undesirable.

Opaque shades shall be provided on windows of radiographic and fluoroscopic rooms, special procedures rooms, cardiac catheterization rooms, and rooms containing image intensifiers.

D.3.5 Systems Furniture

Supplementary space outside the work stations shall be provided for general- and shared-use equipment functions such as fax, copier, printer, or other related equipment functions.

It is recommended that system workstations be designed in generic form. Also, the use of modular and standard casework is recommended so as to minimize maintenance and replacement costs. The Interior Designer must coordinate design decisions with architects and engineers of the design team to resolve such issues as telephone systems, electrical systems, local area networks (LANs), and ventilation systems, and this information shall be provided well in advance of the furniture installation to give technical installers time to provide necessary services. Installation follow-up by the Interior Designer is vital to the overall success of

the project. Documentation must include, but is not limited to, scaled drawings which indicate panel and component locations, accessories, and seating. A component list of parts shall be made a part of the NIH computer data base to support the future reconfiguration of workstations.

D.4 Structural

D.4.1 Vibration

An analysis of vibration response of the structure shall be made. Consideration must be given to vibration of floor-framing systems caused by mechanical and electrical equipment such as pumps, chillers, fans, emergency generators, and transformers and from other sources such as foot traffic, parking garage traffic, and movement of heavy equipment.

Vibration-sensitive procedures and equipment such as optical procedures, electronic equipment, X-ray machines, and NMR equipment must be protected from vibration. Specific vibration recommendations shall be made by an experienced vibration consultant. Steel structures shall not be precluded for use, relative to vibration, without supporting analysis.

To control vibration transmitted into operating rooms or sensitive spaces, the Architect/Engineer shall consider the following items during the early design phases.

- The structural system shall be relatively stiff so that any vibration that is transmitted occurs at high frequencies. Vibrations occurring at higher frequencies are more easily dampened with instrumentation vibration-dampening systems and isolation tables than vibrations occurring at lower frequencies.

- The structural system shall have relatively short column spacing.

- Operating rooms or sensitive spaces shall be isolated from sources of vibration.

- Vibration-sensitive procedures or equipment shall be located on grade-supported slabs.

- On framed floors, the combining of corridors and operating rooms or sensitive spaces in the same structural bay shall be avoided.

D.4.2 Module/Bay Size

The structural bay size shall be based on the required hospital module and functions framed within the structural bay. Particular concern should be given to the operating room suites and functions that require spaces uninterrupted by columns.

D.4.3 Floor Slab Depressions

Floor depressions and/or topping slabs will be evaluated for use in special-finish areas, and wet areas, including patient showers, hydrotherapy rooms, etc. Floor depressions shall be reviewed for equipment requirements to allow for ease of movement of equipment and patients.

D.4.4 Equipment Pathway

The potential routing or pathway for the addition or relocation of heavy equipment shall be reviewed and identified during the design phase.

D.5 Heating, Ventilation, and Air Conditioning

HVAC systems must be responsive to the critical needs of the health care environment. Temperature, humidity , and filtration levels must be carefully controlled. Systems must have adequate ventilation capacity to control odors and airborne contaminants and offset equipment heat loads generated in treatment areas.

HVAC systems must be both reliable and redundant and operate without interruption in the patient care areas. Systems must be designed to maintain the required air-change rate and relative pressure differentials between spaces and must be efficient to operate, both in terms of energy consumption and from a maintenance perspective. Federal Energy Standards must be achieved. An energy monitoring control system shall be provided.

D.5.1 Building Design Considerations

The project engineer shall include at the completion of the schematic design phase a "Basis of Design" report. The report shall be a bound presentation with documentation sufficiently complete to justify the complete design concept of the Architect/Engineer. Detailed building design criteria, computations, schematic system diagrams, economic analysis, and life cycle costing comparisons shall be included as a part of the Basis of Design report.

D.5.2 Energy Conservation

The International Energy Conservation Code shall be utilized to regulate the design and construction of the exterior envelopes and selection of HVAC, service water heating, electrical distribution, lighting systems, and equipment required for the purpose of effective use of energy, and shall govern all buildings and structures erected for human occupancy. When requirements of the energy conservation code cannot be satisfied because of program requirements, the NIH Project Officer shall be notified.

At the completion of the design development phase, a plan review record as defined in the International Energy Conservation Code shall be submitted stamped and signed by a licensed professional engineer showing full compliance with the code.

Minimum system insulation thicknesses shall be as required by the energy conservation code and ASHRAE recommendations. Minimum thickness in all applications shall be sufficient to prevent condensation.

The quality of the building environment shall be supportive of the health and safety of staff and patients. Opportunities for conserving energy resources shall not compromise staff or patient health and safety nor hinder continuous research functions.

Effective energy management requires close, consistent control of all energy consuming systems and components. Evaluations shall be compared to systems employing no heat recovery or energy conversation components. The capital cost, energy cost, maintenance cost, and payback period of the heat reclamation systems shall be evaluated for the use at the NIH.

D.5.3 Systems Economic Analysis

The purpose of the economic analysis is to determine the comparative life cycle costs of various HVAC system alternatives. The analysis shall provide sufficient data to indicate the most economical and energy-efficient system and to permit a comprehensive review of all computations. The analysis shall include and compare total initial capital cost, energy cost, operating cost, system reliability, flexibility, and adaptability for each alternative. Each system alternative considered shall satisfy completely the program requirements as to flexibility, redundancy, reliability, and ease of maintenance. The total capital cost to provide the program requirements for each alternative shall be included as part of the life cycle cost.

D.5.4 Outdoor Design Conditions for the NIH, Bethesda

For facilities whose purpose is health care and for HVAC systems requiring 100% outside air, outdoor design conditions shall be as follows:

Summer:	35^{o}C dry bulb and 25.7^{o}C wet bulb, 12 km/h wind
Winter:	-11.6^{o}C dry bulb, 10.8 km/h wind
Latitude:	39 N, daily temperature range: -8^{o}C

For all other facilities, such as office buildings, administrative facilities and noncritical HVAC systems not requiring 100% outdoor air, the values recommended by current ASHRAE Handbook of Fundamentals shall be used to conform with the following:

Summer: 1% design dry bulb
1% design wet bulb

Winter: 99% design dry bulb

The design wet-bulb temperature for sizing cooling towers shall be 1^{o} higher than the ASHRAE 1% outdoor design wet-bulb temperature.

All outdoor air-cooled condensing equipment shall be designed and selected based on a 41^{o}C ambient temperature.

D.5.5 Hospitals Indoor Design Criteria

Indoor Design Conditions:

The minimum indoor room design conditions shall be as follows in Table No. 1 unless otherwise defined by the Program of Requirements.

Table No. 1
Indoor Design Conditions
(Degree C Dry Bulb and Percent Relative Humidity)

Room or Area	Summer		Winter	
	Db	RH	Db	Rh
Baths & Toilets	24	--	24	--
Blood Bank	21 to 24	50 ± 5	21 to 24	50 ± 5
Cardiac Catheterization	18 to 24	45 to 55	18 to 24	45 to 55
Computer Room	21	40 to 45	21	40 to 45
Dining	24 ± 1	50 ± 5	22	--
Electrical Equip. Room	26	--	18	--
Elevator Machine Room	29	40 to 60	18 to 24	--

Examination Room	24	50 ± 5	24	50 ± 5
Full Term Nursery	24	30 to 60	24	30 to 60
Fluoroscopic, Radiographic and Deep Therapy Rooms	24 to 27	40 to 50	24 to 27	40 to 50
ICUs (Coronary Medical Surgical)	24 to 27	30 to 60	24 to 27	30 to 60
Isolation Room	24	50 ± 5	18 to 24	50 ± 5
Kitchen	29	60	21	--
Mechanical Equip. Room (MER)	35 ± 1	--	10	--
Offices	24	50 ± 5	22	30(MIN)
Operating Room (O.R.)	18 to 24	50 to 60	18 to 24	50 to 60
Patient Room	21 to 24	50 ± 5	21 to 24	30(MIN)
Pharmacy	24	50 ± 5	22	30(MIN)
Physical Therapy	21 to 24	50 ± 5	21 to 24	50 ± 5
Recovery Room	21 to 24	50 to 60	21 to 24	50 ± 5
Special Care Nursery	24 to 27	30 to 60	24 to 27	30 to 60
Supply Processing Distribution Central Sterile	24	--	22	30(MIN)
EtO (Ethylene Oxide) Equip. Room	24	--	22	--
Steam Sterilizer Equip. Room	27 ± 5	--	18	--
Telephone Equip. Room	24	50 ± 5	18 to 24	30(MIN)
Therapeutic Pool	27 to 29	60(MAX)	29	60(MAX)
Tub Rooms	24 to 27	--	24 to 29	--
Clean Utilitu Room	24	50±5	22	30(min)
Chute Room	26	--	18	--
Housekeeping Room	24	--	22	--
Nourishment Station	24	50±5	22	30(min)
Conference Room	24	50±5	22	30(min)
Medication Room	24	50±5	22	30(min)

Treatment Room	24	50±5	22	50±5
Day Hospital Room	21 to 24	50±5	21 to 24	30(min)
Staff/Patient Lounge	24	50±5	22	30(min)

Notes relative to Indoor Design Conditions:

Dual temperature indications (such as 21 to 24**)** are for an upper and lower range at which the room temperature must be controlled.

Dual relative humidity indications (such as 50 to 60) are the minimum and maximum limits where control is specifically needed.

Patient toilet rooms do not require individual room temperature control in cooling mode.

Space temperature for therapeutic pools shall be -15^{o}C less than pool water temperature.

D.5.6 Air Quality

Systems shall provide air free of dust, dirt, odor, and chemical and radioactive pollutants. In some cases, outside air quality is hazardous to patients suffering from cardiopulmonary, respiratory, or pulmonary conditions. In such instances, systems that intermittently provide the maximum allowable recirculated air should be considered.

Adequate access shall be provided for periodic maintenance and cleaning of coils, humidifiers, and drain pans. Drain pans shall be designed and installed for proper and immediate drainage of condensed water. A proper hydraulic head shall be provided for drains within positive and negative air plenums to ensure drainage and prevent overflow. Condensate drain piping shall have a minimum slope of 21 mm/m and be minimum 19 mm in size.

The floor of outdoor air areaways shall be sloped approximately 8% to ensure prompt drainage of rain and snow.

Outdoor intake shall be located as far as practical (on directionally

different exposures) but not less than 9.1 m from exhaust outlets of combustion equipment stacks, cooling towers, ventilation exhaust outlets from the building or adjoining buildings, vacuum systems, plumbing vent stacks, or from areas that may collect vehicular exhaust and other noxious fumes. The bottom of outdoor air intakes serving central systems should be located as high as practical but not less than 1.8 m above ground level, or if installed above the roof, 914 mm above the roof level.

Exhaust outlets shall be located a minimum of 3.0 m above ground, away from occupied areas or from doors and operable windows. The preferred location for exhaust discharge is above roof level. Care must be taken in locating highly contaminated exhausts and discharges from engines, lab hoods, kitchen hoods, and other hazardous sources. Prevailing winds, adjacent buildings, and discharge velocities must be taken into account to ensure that discharge is not entrained within an outdoor airstream.

The use of exposed fiberglass or any fibrous material which allows fibers to break off into the airstream for interior lining or insulation is prohibited for ductwork and air handling units. Sound attenuators or other approved means of noise control shall be used where required. Vaporseal insulation shall be used on the outside of ductwork to prevent condensation.

The use of water sprays for humidification, air plenums for distribution, and fiberglass duct systems is prohibited. Variable air-volume terminal units shall have a minimum setpoint to maintain the required ventilation levels even though the controlling thermostat is satisfied.

Building HVAC systems shall be designed to provide a purge cycle during building start-up and when future renovations occur. The purge cycle employs 100% outdoor air to ventilate away fumes and odors generated by construction materials, furnishing, and finishes. The Architect/Engineer shall develop in the design phase a formal start-up and commissioning procedure that addresses the needs of indoor air quality.

All central ventilation or air-conditioning systems shall be equipped with filters having efficiencies not less than those indicated in the table below. Where two filter beds are indicated,

Filter Bed No. 1 shall be located upstream of the air-conditioning equipment and Filter Bed No. 2 shall be downstream of the supply fan, any recirculating spray water systems, any wet coil surfaces, and water-reservoir-type humidifiers. Appropriate precautions shall be observed to prevent wetting of the filter media by free moisture from humidifiers. Where only one filter bed is indicated, it shall be located upstream of the air-conditioning equipment. All filter efficiencies shall be based on ASHRAE Standard 52-76.

HEPA filters having DOP test efficiencies of 99.97% shall be used on air supply systems serving rooms used for clinical treatment of patients with a high susceptibility to infection from leukemia, burns, bone marrow transplant, organ transplant, or AIDS. They should also be used on the exhaust discharge air from fume hoods or safety cabinets in which infectious or highly radioactive materials are processed and should be designed and equipped to permit safe removal, disposal, and replacement of contaminated filters.

The application of various filter beds for health care units shall be based on Table No. 2:

Table No.2
Filter Efficiencies for Central Ventilation and Air-Conditioning Systems in General Hospitals

Minimum Number of Filter Beds	Area Designation	Filter Efficiencies, %		
		Filter Bed No. 1	Filter Bed No. 2	Filter Bed No.3
3	Orthopedic operating room Bone marrow transplant Organ transplant operating room	30 + 60	90	99.97
2	General procedure operating rooms Delivery rooms Nurseries Intensive care units Patient care Treatment Diagnostic and related services	30 + 60	90	--
1	Laboratories Sterile storage	30 + 80	--	--

1	Food preparation areas Laundries Administrative Bulk storage Soiled holding areas	30 + 60	--	--

Filter Bed No. 1 shall be based on ASHRAE Standard 52-76.

Filter Bed No. 2 shall be based on DOP test.

Filter Bed No. 3 shall have HEPA filters installed at air outlets or in the terminal ductwork adjacent to the room.

D.5.7 Air Movement

Airflow in hospitals and other health care facilities shall be controlled to minimize the spread of contaminants. Undesirable airflow between rooms and floors is often difficult to control because of open doors, the movement of staff and patients, temperature differentials, and stack effect accentuated by vertical openings such as chutes, elevator shafts, stairwells, and mechanical shafts common to hospitals. While some of these factors are beyond practical control, the effect of others may be minimized by terminating shaft openings in enclosed rooms and by designing and balancing air systems to create positive or negative air pressure within certain rooms and areas.

Systems serving highly contaminated areas such as contagious or immunocompromised isolation rooms and autopsy rooms should maintain a positive or negative air pressure within these rooms relative to adjoining rooms or the corridor. The pressure is obtained by supplying more or less air to the area around the perimeters of doors and prevents an outward airflow. The operating room offers an example of an opposite condition. This room, which requires air that is free of contamination, must be pressurized relative to adjoining rooms or corridors to prevent any air movement into the operating room from these relatively highly contaminated areas.

Differentials in air pressure can be maintained only in an entirely closed room. Therefore it is important to obtain a reasonably close fit of all doors or closures of openings between pressurized areas. The opening of a door or closure between two such areas instantaneously reduces any existing pressure differential between them to such a degree as to nullify the effectiveness of the pressure.

When such openings occur, a natural interchange of air takes place because of thermal currents resulting from temperature differences between the two areas.

For critical areas requiring the maintenance of pressure differentials to adjacent spaces while providing for personnel movement between the spaces and areas, the use of appropriate airlocks or anterooms shall be included.

In general, it is recommended that air supply outlets to sensitive ultraclean areas, as well as highly contaminated areas, be located on the ceiling, with perimeter or several exhaust inlets near the floor. This provides a downward movement of clean air through the breathing and working zones to the contaminated floor area for exhaust. In this respect, the bottoms of return or exhaust openings should not be below 75 mm above the room floor.

Laminar airflow in surgical operating rooms is defined as airflow that is predominantly unidirectional when not obstructed. The unidirectional laminar airflow pattern is commonly attained at a velocity of 0.46 mm plus or minus 0.10 m/s.

Laminar airflow systems have shown promise for rooms used for the treatment of patients who are highly susceptible to infection. Among such patients would be the badly burned and those undergoing radiation therapy, concentrated chemotherapy, organ transplants, amputations, and joint replacement. Bench-type units may be used to a great extent in such areas as pharmacy, tissue banks and laboratories.

D.5.8 Air Pressure Relationships

Design of the ventilation system must provide air movement from clean to less clean areas. In critical care areas, constant-volume systems should be employed to assure proper pressure relationships and ventilation except as noted for unoccupied rooms. In noncritical patient care areas and staff rooms, variable air volume systems may be considered for energy conservation. When using variable air volume systems within the hospital, special care should be taken to assure that minimum ventilation rates (as required by codes) are maintained and that pressure relationships between various departments are maintained. A method such as air volume

tracking between supply, return, and exhaust could be used to control pressure relationships when using variable air volume systems. In Table No. 3 those areas that required continuous control are noted with "P", "N", or "E" for positive, negative, or equal pressure. Where ± is used, there is no requirement for continuous directional control.

Because of the cleaning difficulty and potential for buildup of contamination, recirculating room units must not be used in areas marked "No." Note that the standard-type recirculating room unit may also be impractical for primary control where exhaust to the outside is required.

In rooms having hoods, extra air may be supplied to offset hood exhaust so that the designated pressure relationship is maintained.

D.5.9 Ventilation Rates

Minimum room ventilation rates and general pressure relationships shall be as listed below in Table No. 3. Airflow rates may be higher due to cooling loads or exhaust requirements of equipment or hoods.

Table No. 3
Minimum Room Ventilation Rates

Function Space	Pressure Relationships to Adjacent Areas	Minimum Air Changes of Outdoor Air per Hour	Minimum Total Air Changes per Hour	All Air Exhausted Directly to Outdoors	Recirculated Within Room Units
SURGERY AND CRITICAL CARE					

Operating room (all-outdoor-air system)	P	15	15	Yes	No
(recirculating-air system)	P	5	25	Optional	No
Delivery room (all-outdoor-air system)	P	15	15		
(recirculating air system)	P	5	25		
Recovery room	E	2	6	Optional	No
Nursery suite	P	5	12	Optional	No
Trauma room	P	5	12	Optional	No
Anesthesia storage (see code requirements)	±	Optional	8	Yes	No
NURSING					
Patient room	±	2	6	Optional	Optional
Toilet room	N	Optional	10	Yes	No
Intensive care	P	2	6	Optional	No
Isolation	±	2	6	Yes	No
Isolation alcove or anteroom	±	2	10	Yes	No
Labor/delivery/recovery/postpartum (LDRP)	E	2	6	Optional	Optional
Patient corridor	E	2	6	Optional	Optional
ANCILLARY					
Radiology X-ray (surgery and critical care)	P	3	15	Optional	No
X-ray (diagnostic and treatment)	±	2	6	Optional	Optional
Darkroom	N	2	10	Yes	No
Lab, general	N	2	6	Yes	No
Lab, bacteriology	N	2	6	Yes	No
Lab, biochemistry	N	2	6	Yes	No
Lab, cytology	N	2	6	Yes	No
Lab, glasswashing	N	Optional	10	Yes	Optional
Lab, histology	N	2	6	Yes	No
Lab, nuclear medicine	N	2	6	Yes	No
Lab, pathology	N	2	6	Yes	No
Lab, serology	N	2	6	Yes	No
Lab, sterilizing	N	Optional	10	Yes	No
Lab, media transfer	E	2	6	Yes	No
Autopsy	N	2	12	Yes	No
Nonrefrigerated body holding room	N	Optional	10	Yes	No
Pharmacy	P	2	6	Optional	Optional

DIAGNOSTIC AND TREAT-MENT					
Examination room	±	2	6	Optional	Optional
Medication room	P	2	6	Optional	Optional
Treatment room	±	2	6	Optional	Optional
Physical therapy and hydrotherapy	N	2	6	Optional	Optional
Soiled workroom or soiled holding	N	2	10	Yes	No
Clean workroom or clean holding	P	2	6	Optional	Optional
STERILIZING AND SUPPLY					
ETO sterilizer Room	N	Optional	10	Yes	No
Sterilizer equip-ment room	N	Optional	10	Yes	No
Central medical and soiled or de-contamination	N	2	6	Yes	No
surgical supply	P	2	6	Optional	Optional
Clean workroom and sterile storage					
Equipment storage	±	2(Option-al)	2	Optional	Optional
SERVICE					
Food preparation centers	±	2	10	Yes	No
Warewashing	N	Optional	10	Yes	No
Dietary day storage	±	Optional	2	Optional	No
Laundry, general	N	2	10	Yes	No
Soiled linen sorting and storage	N	Optional	10	Yes	No
Clean linen storage	P	2(Option-al)	2	Optional	Optional
Soiled linen and trash chute room	N	Optional	10	Yes	No
Bedpan room	N	Optional	10	Yes	No
Bathroom	N	Optional	10	Optional	No
Janitor's closet	N	Optional	10	Optional	No

Notes Relative to Ventilation Rates:

This table was generally taken from AIA, *Guidelines for Construction and Equipment of Hospital and Medical Facilities*, and ASHRAE, *Applications Handbook*. The values and requirements listed are NIH Standards.

This table covers ventilation for comfort as well as for asepsis and odor control in areas of acute care hospitals that directly affect patient care. ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, shall be used for areas where specific standards are not given. In any case, where a higher outdoor air requirement is called for in ASHRAE Standard 62-1989 than the table above, the higher value shall be used. Specialized patient care areas such as specialty procedures rooms, etc. shall have additional ventilation provisions for air quality control as may be appropriate. OSHA Standards and/or National of Occupational Safety Health (NIOSH) Criteria require special ventilation requirements for employee health and safety within health care facilities.

Total air changes indicated should be either supplied or, where required, exhausted. To satisfy exhaust needs, replacement air from outside is necessary. This table does not attempt to describe specific amounts of outside air to be supplied to individual spaces except for certain areas such as those listed. Distribution of the outside air added to the system to balance required exhaust and maintain the desired pressure relationship shall be as required to comply with the given criteria.

The above table indicates the minimum requirements for ventilation rates for both outside air and total air changes. When a room has a requirement of two and six air changes respectively, this indicates a system mixed air ratio of 33% outdoor air. For this example, when the central system has an outside-air-to-return-air ratio below 33%, the total air changes for the room must be increased to ensure that the minimum outside air requirements are met.

Air from areas with contamination and/or odor problems shall be exhausted to the outside and not recirculated to other areas. Note that individual circumstances may require special consideration for air exhaust to outside, e.g., ICU in which patients with pulmonary infection are treated.

The number of air changes may be reduced to conserve energy when the room is unoccupied if provisions are made to ensure that the number of air changes indicated is reestablished any time the

space is being utilized. Adjustments shall include provision for keeping the direction of air movement the same when the number of air changes is reduced. Areas not indicated as having continuous directional control may have ventilation systems shut down when the space is unoccupied and ventilation is not otherwise needed.

Food preparation centers shall have ventilation systems that have an excess of air exhaust for "inward" air movement when hoods are either operable or inoperable. The number of air changes may be reduced or varied to any extent required for odor control when the space is not in use.

Specific OSHA regulations regarding ethylene oxide (EtO) use have been promulgated. 29 CFR Part 1910.1047 includes specific ventilation requirements for the local exhaust of the EtO sterilizer area.

NIOSH Criteria regarding occupational exposure to waste anesthetic gases and vapors and control of occupational exposure to nitrous oxide indicate a need for both local exhaust (scavenging) systems and general ventilation of the areas in which the respective gases are utilized.

For operating rooms, use of 100% outside air should be limited to those cases where codes require it, and only if heat recovery devices are used.

The term "trauma room" as used here is the first aid room and/or emergency room used for general initial treatment of accident victims. The operating room within the trauma center that is routinely used for emergency surgery should be treated as an operating room.

Although continuous directional control is not required for patient, exam, treatment, and patient corridors, variations should be minimized, and in no case should a lack of directional control allow the spread of infection from one area to another. Boundaries between functional areas (wards or departments) should have directional control.

The isolation rooms described in these standards are those that might be used for infectious patients in the average community

hospital. The rooms are either positively or negatively pressurized depending on the patient. Some isolation rooms may have a separate anteroom.

The nonrefrigerated body-holding room standards would be applicable only for facilities that do not perform autopsies on-site and use the space for short periods while waiting for body transfer to be completed.

D.5.10 Heating and Cooling Load Calculations

Complete design load calculations and a vapor drive study shall be prepared for each space within a design program and presented in a similar format to that outlined in the latest ASHRAE *Handbook of Fundamentals*. Heating and cooling load calculations are required for all projects to facilitate review and provide a reference for system modifications. Individual room calculations shall be generated and summarized on a system basis and presented with a block load to define the peak system load. Load summary sheets shall indicate individual rooms with area, design air quantity, liters per second per square meter, and corresponding return or exhaust air quantity. Calculations shall include but not be limited to indoor and outdoor design parameters, heat gains and heat losses, supply and exhaust requirements for central systems, and, for each area of the facility, humidification and dehumidification requirements and heat recovery. As a reference, calculations for assessing heating and cooling loads may include but are not limited to the following:

<u>Sensible Heat Loads</u>:
Windows, solar/conduction components
Walls, external, external chases
Roofs and skylights
Floors, when above unconditioned spaces
Ceilings, when below unconditioned spaces
Partition, when next to unconditioned spaces
People, sensible
Animals, sensible
Lights, room, and task
Internal equipment and personal computers
Supply, return, and exhaust fan heat
Infiltration

Makeup and ventilation and requirements
Auxiliary air requirements

Latent Heat Loads:
People, animals, internal equipment
Infiltration
Makeup and ventilation air requirements
Auxiliary air requirements

All heating and cooling load calculations shall include a predetermined safety factor to compensate for load inaccuracies, future flexibility, infiltration, and air leakage. Safety factors shall be clearly defined in the Basis of Design report.

D.5.11 Building Solar and Conduction Loads

The Design Engineer shall provide a thorough review of all building construction components to accurately calculate the resultant R and U values for the various construction conditions. Calculations shall include a sketch of the construction condition and include a written description of where the condition exists. Component R values used shall be referenced as to their source and, where possible, tied to project specification. R and U values, shading coefficients, vapor transmission values transmittance, doors, windows, and skylights shall be selected by the Architect/ Engineer and accurately defined in the project specification.

D.5.12 Lighting Loads

The design lighting loads in a hospital environment can be highly diverse and a function of the use and occupancy of individual spaces. The Design Engineer shall thoroughly review the electrical design documents to ascertain the lighting levels for individual spaces. Lighting levels will be based on electrical design policies and guidelines. General-use areas shall be designed to accommodate the following minimum levels:

Patient Rooms:

Task lighting:	250 W/person
Room lighting:	32 W/nm^2

Office/Administration/Areas:

Task lighting:	250 W/person
Room lighting:	32 W/nm^2

Corridors:

General lighting:	16 W/nm^2

Dining Rooms:

General lighting:	32 W/nm^2

Operating Room:

Task lighting: as required for special lighting units

General lighting:	43 W/nm^2

Other Areas:

Task lighting: as required for the task

General lighting:	32 W/nm^2

D.5.13 Occupancy Loads

In the absence of more specific program requirements, the following occupancy loads shall be used as a general guide for HVAC calculations during the facility design. The Architect/ Engineer shall review the actual occupancy load relative to these general loads with the NIH Project Officer prior to starting the HVAC design work.

Offices:	13 nm^2 per full-time employee (FTE)
Patient care and treatment areas:	22 nm^2/FTE
Patient rooms:	One bedroom - two people Two bedrooms - four people
Operating rooms:	As specified by users

D.5.14 Equipment Loads

Cooling capacity shall be provided for the following loads dissipated by electrical/electronic equipment including personal computers.

Patient rooms:	22 W/nm^2
Intensive care patient rooms:	43 W/nm^2
Operating rooms:	86 W/nm^2 plus requirements for special equipment
Offices:	43 W/nm^2
Dining rooms:	11 W/nm^2
Other areas:	22 W/nm^2 plus requirements for special equipment

D.6 Plumbing

Plumbing systems shall be coordinated with the hospital program requirements. Piping distribution method including mains, risers, and branch lines shall be designed to accommodate easy service isolation and system maintenance while minimizing disruption to treatment functions. Emergency isolation valves must be conveniently located on branch lines so that segments can be taken off line quickly in the advent of failures.

Health care facilities often have a highly diverse plumbing fixture selection that requires a thorough review of program functions and equipment interfaces. Specialty faucets, fittings, drainage lines, and backflow prevention devices frequently occur.

Piping systems shall be designed for flexibility and have redundant components to provide reliable and continuous operation. Adequate fluid temperature, pressure, and volume must be delivered to required laboratory function through conservatively sized pipe mains. Future capacity allowances need by considered in building designs.

Medical gas systems shall be provided where required and installed to meet NFPA Standard 99. Care shall be taken in locating both the intake for medical air compressor and the discharges for vacuum and gas evacuation systems. The systems must be reliable and have redundant components as they serve critical life support equipment.

D.7 Electrical

D.7.1 Normal Power

The following load figures in voltamperes per square meter shall be used in sizing the overall building service. These figures are connected load and should be used in the early design stages. Actual design loads shall be used in the later part of the design. The range provided is to allow for varying intensity of usage. The mechanical loads do not include chilled water or steam generation, which are produced centrally on the NIH campus. The Engineer shall use sound judgment in applying these numbers.

Load	VA/m^2
Lighting	27 - 38
Receptacles	38 - 54
HVAC	65 - 86
Elevators	11 - 16
Miscellaneous	11 - 22
Total Range	152 - 216

The following are NFPA range Standard 70 Code requirements of note:

Panelboards serving patient critical care areas shall have the ground buses bonded together with a minimum #6 AWG ground conductor. This includes normal and emergency panels

Patient care circuits shall be in metallic conduit for redundant ground

Receptacles in pediatric and psychiatric areas shall be tamperproof. Two prong plugs shall operate tamperproof receptacles. The color coding of receptacles shall remain.

Operating room isolated power circuits shall have a #10 AWG ground conductor connected to the receptacle ground lug. Operating rooms circuits shall be in conduit

Isolated power circuits shall use XHHW insulated conductors to

reduce leakage current

Hospital normal electrical service with voltage higher than 150 V phase to ground shall have two levels of ground fault at the service entrance. The main and feeders in the secondary switchgear shall have coordinated ground fault protection.

Aluminum conduit shall only be used in MRI areas within the 1-gauss line of the magnetic field.

D.7.2 Emergency Power

Loads connected to emergency power (essential electrical system) shall be in accordance with NFPA Standard 70, Article 517, Health Care Facilities.

The following load figures in watts per square meter shall be used in sizing the generator. These figures are connected load and should be used in the early design stages. Actual design loads shall be used in the later part of the design. The range provided is to allow for varying intensity of usage. The Engineer shall use sound judgment in applying these numbers.

Load	W/m^2
Lighting	1 - 5
Receptacles	1 - 2
HVAC	1 - 32
Elevators*	2 - 2
Total Range	5 - 41

*Minimum:1 elevator per bank of elevators

Receptacles in pediatric and psychiatric areas shall be tamperproof. Two prong plugs shall operate tamperproof receptacles. The color coding of receptacles shall remain.

The operating room shall derive power from isolated power panels with line isolation monitors (LIMs). The panel may be located recessed in the room or outside the room with a remote LIM in the room. A 7.5 kVA transformer is recommended; however, if the

demand load is greater, two panels should be provided. The operating room panels shall be connected to emergency power.

D.7.3 Lighting

The lighting levels listed below in lux shall be used for design purposes. The values listed are average maintained footcandle levels using a total maintenance factor of 75%. The numbers listed are target values and shall be adjusted to meet the research requirements.

Function/Space	Lux
Operating rooms	1075 - 2150
Medication prep	1075
Nurse's station	525 - 1075
Patient room	110
Patient reading	325
Patient corridors, day	110 - 220
Patient corridors, night	55 - 110
Offices	525 - 800
Corridors	325 - 525
Stairwells	110 - 220
General storage	220 - 325
Mechanical/electrical rooms	220 - 430

Areas not identified above shall use the Illuminating Engineering Society of North America (IESNA), *Lighting Handbook* for recommended values.

Fluorescent lighting fixtures in operating rooms shall have hybrid magnetic ballasts with cathode cut-off circuitry. The lens shall have Radio Frequency Interference (RFI) shielding and each ballast shall have an RFI suppressor on it.

Inpatient rooms shall have a 600 mm x 1200 mm**,** four-lamp fluorescent "exam" light over the bed on a separate switch. The switch shall be located at the head of the bed on the room door side of the bed. A patient bed light shall be mounted on the headwall above the bed. The bed light shall have three lamps, one directed down for reading and two directed up for general illumination. A

pull-string switch shall control the lighting, sequentially turning on one lamp or two or three. This type of switch only comes in 120 V rating. A recessed, wall-mounted fluorescent PL-7 night-light shall be located, such that a nurse can find the bed in an otherwise dark room and patients can see their way to the bathroom. The night-light shall be connected to emergency power and shall be controlled centrally by an astronomical time clock. A switch at the door in each room shall have local control.

D.7.4 Nurse Call

A voice communication nurse call system shall be provided in patient care areas. The system shall be designed using the Rauland Responder III system. The nurse call system shall be installed in conduit. The nurse call system shall be capable of zone paging through the paging system.

The NIH Project Officer for a particular project shall perform whatever action is necessary to obtain the desired compatible equipment. This may require a Justification for Other Than Full and Open Competition (JOFOC) or it may require that the NIH purchase the equipment directly for installation by the Contractor.

D.7.5 Paging

The existing paging system amplifiers in Building 10 shall be reused unless additional zoning is required. A paging system shall be installed in conduit. The speakers shall have multitap transformers and shall be installed in back boxes. Speaker wiring shall be #16 AWG two-conductor spiral-shielded Carol No. C2892 or Belden No. 8790, or an approved equal.

D.7.6 MATV

A master antenna system for television (MATV) to distribute off-air programming exists in Building 10. The cable shall be RG-6/ U 75 ohm with #18 AWG solid copper conductor coax cable, Belden No. 9248 or an approved equal. The MATV cable shall be installed in conduit.

D.7.7 CATV

Where Montgomery Cable (CATV) is desired, it shall be installed in conduit.

D.8 General Health and Safety

The NIH, through the Division of Safety, has developed a comprehensive Occupational Safety and Health program to protect the safety and health of all employees at the campus. Safety and health regulations and guidelines require the use of engineering controls for worker protection, wherever possible, to minimize the potential for occupational exposure to hazards in the workplace. To be most effective engineering controls for protecting occupational safety and health must be designed into facilities for both new construction and renovated space. This proactive approach can minimize numerous common potential health and safety concerns in laboratory facilities.

These health and safety guidelines are to be incorporated as appropriate in facility-specific construction documents by the Architect/Engineer to ensure health and safety protection is engineered in at the time of construction of the facility(ies).

While many of the requirements for health and safety engineering are incorporated in these guidelines, it is impossible to cover all possible concerns. The architectural/engineering firm should, whenever possible, have a health and safety specialist on staff, and should always consult with NIH Division of Safety personnel with regard to specific health and safety engineering requirements in the design of new construction and renovation projects.

D.8.1 Chemical Hazards

The use of chemicals in the hospitals is of particular concern with regard to occupational safety and health. Chemical usage in the hospital occurs in a number of different areas and design considerations should be made for appropriate ventilation, storage, and waste management requirements. The term “chemicals” includes disinfectants, sterilants, laboratory chemicals, office chemicals, and pharmaceuticals (i.e., chemotherapeutic agents). The architect/engineer firm should consult with personnel from various departments to determine the types and quantities of chemicals in use in the departments and should obtain assistance from NIH Division of Safety personnel with regard to acceptable engineering controls to minimize potential occupational exposure.

The use of ethylene oxide (EtO), a potential carcinogen, as a sterilizing agent is one area that must be addressed. OSHA has promulgated a specific standard, 29 CFR 1910.1047, for protection against occupational exposures to EtO. Appendix A, Part VII, Subpart I of the Standard provides workplace design criteria and recommendations. The standard also requires labeling of regulated (EtO use) areas, the availability of an emergency eyewash and shower, and other operational requirements. Review of these requirements is important before developing overall design specifications.

Formaldehyde (Formalin) is widely used in pathology laboratories and autopsy suites. OSHA has also promulgated a specific standard, 29 CFR 1910.1048, for the protection of workers from exposures to formaldehyde. This standard also contains requirements for point-source ventilation engineering controls, as well as ventilation requirements for areas where the material is to be used. Architects and Engineers should review the requirements of the standard before developing overall design specifications.

The use of other toxic and hazardous chemicals in the hospital may require specific attention to engineering controls in order to minimize potential occupational exposure. The Architect/ Engineer must consult with NIH Division of Safety personnel with regard to the use and control of hazardous chemicals in the facility prior to developing the design specifications.

Specific attention should be given to the pharmacy when considering ventilation requirements for the chemotherapeutic admixture areas. Class II biological safety cabinets are recommended for the handling of chemotherapeutic materials (see the Biological Safety Cabinets section in the Laboratory Guidelines, section D.10).

D.9 Biological Hazard Safety

Biohazardous materials in hospitals are related to patient care and to laboratory work associated with patient derived materials. The Architect/ Engineer should refer to the Research Laboratory Guidelines when designing hospital laboratories.

D.9.1 Hospital Laboratories

Hospital laboratory design and construction should generally follow the design criteria for BL2 research laboratories. Consideration should be made for BL3 laboratory space when infectious agents requiring BL3 containment (i.e., Mycobacterium tuberculosis, etc.) are routinely expected to be used in the hospital laboratory. The final decision on the level of containment should be made by consultation with laboratory supervisory staff and the Division of Safety personnel.

D.9.2 Patient Care Areas

Provisions shall be made for installation of containers to dispose sharps in all patient care areas.

Isolation Rooms: Requirements for ventilation of isolation rooms can vary depending upon the use of the room. Some isolation rooms are used to protect immunosuppressed patients from infection by organisms present in the hospital, while others are used to protect patients and hospital personnel from infectious agents carried by specific patients.

Isolation rooms for prevention of patient (immunocompromised patients) exposure to potentially infectious materials in the hospital environment.

These rooms require HEPA-filtered supply air and are kept at a higher pressure than the surrounding area. Restricted access is required and a ventilated anteroom/airlock must be provided.

Isolation rooms are also important in the minimization of transmission of communicable infectious diseases (tuberculosis (TB), etc.) from infected patients to noninfected patients and

hospital staff.

Appropriate design of these rooms includes consideration of negative pressure ventilation, possible HVAC exhaust filtration, and an anteroom/airlock provision. Exhaust from these isolation rooms must be directed to the outside of the building, away from any building air intakes, etc.

HVAC: TB patient isolation rooms must have a minimum of 12 total air changes per hour, as proposed by the CDC, including at least 2 outside air changes per hour. The room must be at a lower pressure than the surrounding areas, and no recirculation of exhaust air from the isolation room is to be allowed.

Directional airflow must be monitored and some method of ensuring such monitoring should be considered in the design of these rooms.

An anteroom/airlock must be provided.

Treatment Rooms: Treatment rooms in which patients with possible TB are treated should be designed with the same HVAC criteria as are the TB patient isolation rooms.

Consideration should be given to designing local exhaust ventilation in specific areas of treatment (i.e., pentamidine treatment booths) in order to minimize potential occupational exposure to patient secretions.

Autopsy rooms: Autopsy rooms should have ventilation that provides at least 12 total air changes per hour, have good distribution of airflow in the room, be at a negative pressure with respect to adjacent areas, and be exhausted directly to the outside of the building.

Formaldehyde and other volatile toxic chemicals are used in pathology. Appropriate removal of these materials to minimize occupational exposures is required. Downdraft tables and other local exhaust methods should be considered in developing the design of ventilation for autopsy rooms.

Exhaust: Air from isolation, treatment, and autopsy rooms should

be exhausted directly to the outside of the building, away from intake vents, people, and animals and in accordance with Federal, State, and local regulations concerning environmental discharges. (See CDC, Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, 1994)

D.10 Radiation Safety

Work performed at the NIH hospitals involves the potential for occupational exposure to radioactive materials and other sources of ionizing and nonionizing radiation. While, generally speaking, the procedures identified as good radiation safety (health physics) practices and techniques are essential to minimize potential exposure to radiation, security, containment, and shielding of this material and equipment through the use of good facility design are other extremely important elements.

The intent of this section is to provide Architects/Engineers and construction contractors with a working knowledge of the facility design parameters required for the construction of facilities which must provide for the control and containment of these radiation hazards.

Not all sources of ionizing radiation are covered by Nuclear Regulatory Commission (NRC) licensing. These nonlicensed sources are, however, controlled by regulations issued by the NIH Radiation Safety Committee upon recommendation by the Radiation Safety Officer. Nonlicensed sources include X-ray machines, high-voltage accelerators, electron microscopes, and radioactive materials from sources other than reactor by-products.

In addition to the protection of occupationally exposed workers, the NIH Division of Safety, Radiation Safety Branch has to ensure that the general public and surrounding environs are also provided with an adequate and similar degree of protection.

D.10.1 Background

The *National Institutes of Health Radiation Safety Guide* provides guidance and technical information concerning the use of radioactive materials as well as policies and procedures for radiation-producing machines and areas. Radiation safety control, containment, and shielding design and laboratory practices have been developed to minimize the potential for radiation exposure to workers as well as release to the environment.

D.10.2 Specific Areas of Concern

The following key radiation issues were identified relative to hospital activities:

- radiation safety requirements for hospitals using radionuclides

- radioactive airborne and liquid effluent sampling

- radiation safety requirements for devices used in medical research such as X-rays, accelerators, and irradiators

- radiation safety requirements for nonionizing radiation (only MRI and high-intensity lasers (e.g., CO_2)

- security of radioactive materials

All radioactive materials stored at any NIH facility shall be secured, i.e., unattended areas in which radionuclides are in use or stored must be locked or radioactive materials must be locked in containers, refrigerators, or freezers. In addition, besides locked doors, other security options may be implemented, e.g., card key access, etc.

D.10.3 Radioactive Waste Storage

On-Campus Buildings: Hospital buildings on the NIH campus shall be designed with a separate area for temporary staging of hazardous and radioactive waste. Mixed waste (hazardous waste that is also radioactive) shall be treated as radioactive waste in this temporary staging area. These staging areas are discussed in detail in the Hazardous Waste Storage section of these specifications. Only the specific issues which are directly related to radioactive waste are discussed here.

Information on the carts and equipment for the transfer of radioactive waste currently in use can be obtained from the NIH Division of Safety, Radiation Safety Branch.

The staging area shall be large enough to provide for temporary storage of the radioactive waste and capacity for storage of specialized carts used to transport the radioactive waste from the laboratories. The staging area shall be designed to contain any spills of a radioactive waste that may occur due to handling of the waste materials. It is anticipated that this will be accomplished using specialized carts; however, the Designer may propose

alternate means for spill containment.

Special consideration must be given to this area in the fire protection design as indicated in NRC Information Notice 90-09, which specifies the description of the fire protection and suppression system to minimize the likelihood and extent of fire.

Coolers and/or walk-in freezers used to store medical pathological waste (MPW) will also be used to store animal carcasses, tissues, and bedding contaminated with radioactive materials. Coolers and/or walk-in freezers shall be located in each building.

Hospital Module Requirements: All hospital modules shall be designed for the safe storage of radioactive waste. The volume of radioactive waste generated by a module is a function of the type of work being performed. Thus, the Designer needs to consider the function of the module to determine the space necessary for radioactive waste storage. Some types of radioactive waste will require segregation from other types, and the radioactive waste storage area shall be designed to accommodate multiple containers.

All hospital modules which will use radioactive materials shall be designed to fit the appropriate low-level radioactive waste (LLRW) storage receptacles and/or containers. The Radiation Safety Branch shall be contacted for specifications on these containers. Five LLRW streams have been identified for laboratories from the *NIH Waste Disposal Calendar*, as amended in 1995.

- liquids
    - aqueous waste
    - solvents/other hazardous chemical constituents (mixed waste)
- dry or solid waste (dry active waste)
    - disposable labware
    - sharps (can also be categorized as MPW if not contaminated with radioactive material.)
- liquid scintillation vials and/or bulk liquid scintillation media

- animal carcasses and/or tissues

- animal bedding and/or solid excreta

The size of the space dedicated to these of the containers shall be based upon the volume of radioactive materials generated and/or research activities performed. Standard-sized containers are available from the Radiation Safety Branch and the radioactive waste contractor and should be considered in the design.

The location of the radioactive waste storage shall be standardized to assist emergency response personnel. It is recommended that this storage be located near the module door for convenient access by the technician collecting the radioactive waste. For modules with a service corridor, it is recommended that this storage be located near the service entrance rather than the hall entrance. This will avoid the need for moving radioactive waste through the main corridors of the building.

The configuration of the radioactive waste storage area shall be designed to facilitate radioactive material spill cleanup and decontamination. Interior surfaces of the storage area shall be readily cleanable for ease in decontamination.

The Designer shall also include the following considerations in the design:

- All modules must have the ability to be locked against unauthorized access

- All radioactive materials shall be secured when unattended

- The space required for shielding the waste containers shall be considered

- Modules and marshaling areas should be sized appropriately to reduce accumulation

- Appropriate spill containment shall be included in all storage areas

- Potential shielding requirements between adjoining or

adjacent bench areas for high energy beta emitter radionuclides

- If the module is to be used for higher energy gamma emitter radionuclides, then the design of the countertops and hoods should take into account and compensate for the additional weight required for the appropriate lead shielding

- Secure equipment alcoves should be considered for storage of radioactive materials and/or irradiator equipment

- If there is a need to store radioactive materials in refrigerators and/or freezers, the design specifications should include security provisions, e.g., locks as part of the integrated system, to secure this equipment

- Corridors and public space shall not be designated and used for storage, and equipment such as refrigerators and freezers shall not be designated to store this material in these areas.

D.10.4 Module Requirements

Beta barriers for shielding energetic beta emitters (P-32), often transparent plastic (lucite) sheets, 0.95 to 1.27 cm thick, should be considered to protect personnel working in adjacent and close proximity work areas.

D.10.5 Clearance for Renovation/Remodeling

The NIH Division of Safety, Radiation Safety Branch shall be notified prior to any renovation or remodeling in modules using radioactive material. The module shall be surveyed by the Principal Investigator or authorized users, and the Radiation Safety Branch will conduct additional confirmation or clearance surveys prior to release of the module for unrestricted use, if necessary.

Ventilation systems used for controlling airborne radioactive discharges require design considerations. Exhausts shall be manifolded into the regular building exhaust. Hoods used for bulking RAM shall have the capability for sampling. In addition, the design should also accommodate space in the mechanical room to provide for any future additional filtration capability.

If the facility requires additional hoods, specifically for the use of iodination techniques, then the exhaust from these installations shall be equipped with the capability for HEPA or charcoal filtration. Distinct installation should be considered, separate from the main exhaust system or the main exhaust system.

D.10.6 Radioactive Airborne and Liquid Effluent Discharges

NIH design guidance and policy prohibits discharge of radioactive material into sinks. Provision should be made for installation of appropriate sampling probes for sampling capability to assess airborne and liquid effluent discharge streams, including main exhaust systems, sufficient to demonstrate compliance with the requirements of 10 CFR 20.1302.

Liquid effluent monitoring can be accomplished by batch, composite, or continuous sampling prior to discharge into the sanitary sewer system.

The design and construction considerations for airborne radioactive effluent monitoring should also include the following:

- All systems for use with radioactive materials should have the capacity to sample the airborne effluent being discharged, primarily gases and vapors

- Sufficient capacity should be provided for sampling the combined discharge, specifically gases and vapors at a common point located inside the mechanical room downstream of the filters and fans

- Where iodination is performed in specific modules, those hoods shall be equipped to accept appropriate HEPA and charcoal filters

- Airborne radioactive effluent monitoring systems should be designed in accordance with American National Standards Institute (ANSI) Standard N13.1, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities (1969), specifically Appendix A, Guides for Sampling from Ducts and Stacks

- A single-nozzle sample probe should be designed inside the air-stream for gas and vapors sampling, as specified in ANSI Standard N13.1**.**

Hospital design considerations should also include state-of-the-art design considerations, as specified by ANSI and other acceptable industry standards, such as

- National Council on Radiation Protection and Measurements (NCRP) Report No. 59, *Operational Radiation Safety Program*, Chapter 3, November 1, 1980

- Hanson and Blatz, *Radiation Hygiene Handbook*, Section 9, Facility Design, 1959

- Epoxy coatings, laminates, floor coverings, and protective coatings should be utilized for ease of decontamination and to provide a protective coating which can be readily removed without extensive damage to the existing facility and surfaces

- Sinks should be either plastic composite or coated with epoxy or equivalent to ease the decontamination of surfaces

- Stainless steel is also an option for sinks, however, soapstone shall not be used

- Air filtration systems (activated charcoal/HEPA filtration) shall be installed and tested in accordance with ANSI/ American Standard of Mechanical Engineers (ASME) Standard N510-1980, *Testing of Nuclear Air Cleaning Systems.*

The activated charcoal and HEPA filters shall be tested with current state-of-the-art methods and techniques for filter efficiency and compliance with technical specifications at the factory and postinstallation at NIH facilities.

Chemical fume hoods for radionuclide use should be designed in accordance with the following industry criteria and technical specifications:

- Landis and GYR Powers, Inc., *Laboratory Control and Safety Solutions Application Guide*, 1993

- American Council of Governmental Industrial Hygienists, Industrial Ventilation A Manual of Recommended Practice

- Hoods should have a minimum face velocity of 100 fpm

A typical chemical fume hood designed for hazardous materials is acceptable as a radioisotope fume hood. The hood design should include smooth, nonporous surfaces for ease of decontamination. In addition, the fume hood should be constructed of materials that will not generate mixed waste if the surfaces and the construction materials interact with the radioactive materials.

D.10.7 Vacuum Systems

Vacuum systems should be protected with appropriate filtration (0.3 micron hydrophobic filter or the equivalent) to minimize the potential for contamination of vacuum pumps. Filters shall be on the suction side of the pumps, with exhaust to the outside of the facility and not recirculated into the mechanical spaces.

Filters should be located as close as possible to the laboratory in order to minimize the potential contamination of vacuum lines and to preclude and minimize decontamination and decommissioning costs.

Filter housings shall be designed for easy filter replacement in order to minimize the possibility of maintenance worker contamination and to provide for easy disposal.

D.10.8 Irradiators Utilized in Medical Research

Irradiators are designed to contain significant amounts of radioactive material and therefore are designed with engineering controls as well as adequate shielding to perform the necessary functions utilized in medical research. However, the following facility design parameters are required for the construction to adequately house this equipment

- Floor loads must be assessed to ensure structural integrity

given the amount of shielding and associated weight of this equipment

- Consideration should be given to the available means for moving this equipment to its location (e.g., loads on elevators)

- Because of the shielding requirements, this equipment is usually located on the lower floors of a facility (e.g., ground floor, basement, or sub-basement)

- The NIH Division of Safety, Radiation Safety Branch, shall be contacted when the design and installation of an irradiator is considered

- The room or facility housing the irradiator must be secured or have the capability to be secured (locked).

D.10.9 Radiation-Producing Equipment and/or Machines

In accordance with the NIH *Radiation Safety Guide*, the NIH Division of Safety, Radiation Safety Branch must be notified when there is any change in the setup of radiation producing equipment or machines. This includes purchase and installation of new equipment, changes in shielding, changes in the output of the radiation, or changes in usage of the unit.

With respect to use of radiation-producing equipment and/or machines, the following design guidance should be used:

- *National Council on Radiation Protection and Measurements (NCRP), Report No. 102, "Medical X-Ray, Electron Beam and Gama- Ray Protection For Energies up to 50Mev (Equipment Design, Performance and Use) (1989)"*

- NCRP, Report No. 49, *Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies up to 10 MeV*, September 15, 1976, Washington, DC

The documents referenced above shall be used by the Radiation

Safety Branch to

- Implement an ALARA program to minimize radiation exposure to occupationally exposed individuals and the general public

- Provide the appropriate design criteria as they relate to radiation producing equipment and/or machines

- Provide structural shielding requirements for any new installations or installations undergoing renovations or changes

The following factors such as W (workload), U (use factor), and T (occupancy factor), as defined in the appropriate NCRP handbooks, shall be utilized to calculate and design the necessary shielding requirements. The dose equivalent limit for design purposes shall be 10 mRem public exposure and 500 mRem occupational exposure.

D.10.10 Non-Ionizing Radiation

This section applies only to MRI and high-power intensity lasers.

With respect to the use of MRI devices, the following regulations and design considerations apply:

- U.S Food and Drug Administration (FDA) regulations 21 CFR 892.1000, Magnetic Resonance Imaging

- security requirements for housing and enclosing the equipment

- warning placards, signs, and postings, which may also include barriers

- warning requirements for cardiac pacemakers as well as other prosthetic devices and/or equipment

- shielding requirements to minimize radiation exposure to electric and magnetic fields

- posting concerning electrical hazards

With respect to the use of lasers, specifically high-power intensity lasers, the following regulations and design considerations apply:

- FDA regulations 21 CFR 1040, Performance Standards for Light-Emitting Products

- ANSI Standard for the Use of Lasers, ANSI Standard 2136.1, 1986

- *Connference of Radiation Control Program Directors Frankfort, KY. Suggested State Regulations for Control of Radiation, Volume II: Non-Ionizing Radiation* (Latest Edition).

- Security requirements for housing and enclosing the equipment

- Warning placards, signs, and postings, which may also include barriers

- Appropriate personal protective equipment warnings prior to entering and/or working with the equipment to mitigate and prevent eye and skin exposure

A Class III laser system medium-pulse system requiring control measures to prevent viewing of the direct beam. Design and control measurers emphasize preventing direct access to the primary or reflected beam. Safety eyewear is necessary and required with this class of laser.

High-power intensity lasers (e.g., CO_2 lasers) are classified as Class IV lasers in 21 CFR 1040. These lasers produce radiation so powerful that they can cause injury with a direct or reflected exposure, even when the beam is scattered or diffused by a rough surface or smoke scenes.

Laser facilities should be designed to minimize the use of reflective/refractive surfaces to provide additional protection to occupational workers.

D.11Environmental Management

This section describes the general requirements and specific goals for managing environmental issues on the NIH campus. Specific issues that are addressed in this section include:

- hazardous materials storage and handling
- hazardous waste storage and handling
- bulk storage facilities
- wastewater discharges
- solid waste management and recycling

Attention to environmental management issues and proper waste handling are key portions of NIH's overall goals of ensuring the health and well-being of NIH employees, visitors, and neighbors and maintaining the NIH campus atmosphere.

D.11.1 Background

These guidelines regarding environmental management on the NIH campus encompass the current Federal and State of Maryland regulations regarding environmental management issues. They also include the requirements of local governments and agencies such as the Washington Suburban Sanitary Commission (WSSC) and Montgomery County, Maryland.

Federal laws applicable to environmental management on the NIH campus include

- the Resource Conservation and Recovery Act
- the Clean Water Act
- the Safe Drinking Water Act
- the Clean Air Act
- the Hazardous Materials Transportation Act

Certain environmental issues have been purposely excluded from this section of the Guidelines because they are fully addressed in the Reference Materials, Section G, Site/Civil. These issues include stormwater management and sediment control; erosion control; wetlands and use of fertilizers and pesticides in landscaping and groundskeeping.

The requirements contained in these guidelines upgrade the previous NIH design policy and guidelines which contained little discussion on environmental protection issues.

D.11.2 Hazardous Substance Storage and Handling

All NIH hospital facilities shall be designed to minimize the use of hazardous substances. Alternative nonhazardous or nontoxic materials shall be preferred in all new construction and renovations. The Designer shall develop a plan for eliminating the use of hazardous substances. Where hazardous substance use is unavoidable, the Designer shall demonstrate that alternate nonhazardous substances are either not available, inferior to the hazardous substance, or cost prohibitive.

Examples of hazardous substances that should be avoided include but are not limited to: Oil-based paints and caulks; hazardous cleaning, surface preparation, and paint-stripping solvents; and petroleum-based contact adhesives.

In general, most new construction will result in the release (off-gassing) of odors that can affect worker comfort. If hazardous substances are avoided in the construction, these odors will generally be nonhazardous; however, they can still have a detrimental effect on indoor air quality. Examples of nonhazardous substances that can affect indoor air quality include systems furniture, carpets, and latex paints.

New facilities shall be allowed to off-gas prior to occupancy. Ventilation systems on new construction should be operated for at least 1 month before the building is occupied. For renovations, where it is not feasible to isolate the NIH employees from the off-gassing, materials which are going to off-gas and affect indoor air quality should be allowed to air out and off-gas in a warehouse or

well-ventilated, unoccupied area before they are installed.

D.11.3 Hazardous Substances Storage

Hospital Building Receiving Areas: Hazardous substances used at NIH fall into two categories. They are either substances used in the facility directly by the research activity, or they are substances used in support of the facility. An example of the hazardous substances used directly by the research activity is chemicals used for analytic purposes. An example of the hazardous substances used in support of the research facility is chemicals used for washing of glass or neutralization of wastewater discharges.

Hazardous substances that will be used in the facility directly in the research activity will be delivered directly to the end users. Therefore, a staging and temporary storage area will not be required in the receiving area for these materials.

Materials that will be used in support of a facility must be placed in a hazardous substance storage area. In general, these materials are received in 220 L drums or larger. Storage capability should exist in areas for up to 10 drums. Some neutralization materials may be stored in bulk containers up to 1,600 L.

Each building utilizing these hazardous substances shall be designed with a receiving and storage area. This area should be located at or near the point of use of the materials and will be used for long-term storage of hazardous materials.

Hazardous substance storage areas shall be out of the normal flow of personnel traffic. There shall be convenient access from the storage area to the freight elevator and/or the loading dock without having to traverse heavily traveled corridors.

The staging area shall be large enough to provide storage of the hazardous substances and room for loading and unloading the drums or containers. If multiple substances will be stored, the design shall allow for incompatible materials to remain segregated while in storage.

The storage area shall be designed to contain any spills of hazardous substances that may occur due to handling or

mishandling. Spill containment may be accomplished with a curb around the area, secondary containment bins, shelving designed to contain spills, or a combination thereof. A chemical-resistant coating shall be applied to the walls and floor in this area to make it easier to clean up spills.

Safety equipment shall be provided for each staging area. This safety equipment shall consist of a first aid kit, emergency eyewash, and emergency shower. Special consideration must be giving to this area in the fire protection design if flammable materials will be stored.

Individual Modules: All individual modules in the hospital buildings shall be designed for the safe storage of hazardous substances while discouraging the storage of excessive amounts of hazardous substances. Thus, the Designer needs to consider the function of the module and the potential use of hazardous substances to fulfill this function.

All modules shall contain an approved flammable materials storage cabinet. The size of this cabinet shall be based upon the anticipated volume of flammable materials to be used. The location of the storage cabinet shall be standardized in the hospital buildings to assist emergency response personnel.

Hazardous substance storage cabinets shall be placed to allow the cabinet to be ventilated, if needed. The Designer shall consider the purpose of the module and the likely chemicals that will be stored in the cabinet to determine if one or more vented storage cabinets is required.

An additional storage area for nonflammable hazardous substances shall also be provided. This storage area shall have at least two distinct segments to allow segregation of incompatible materials. Each segment of the storage area shall be designed to contain a spill of at least 1 gallon of hazardous substance. The configuration of the storage area shall be designed to facilitate spill cleanup. Interior surfaces of the storage area shall be cleanable, corrosion resistant, and nonreactive.

Hospital Buildings: Hospital buildings on the NIH campus shall be designed with a room for temporary storage of hazardous waste and radioactive wastes. Mixed waste (hazardous waste that is also radioactive) shall be treated as radioactive waste in this temporary storage area. Hazardous waste is generally stored in this room for several hours, although it may be stored overnight.

The room shall consist of two individual segments, one for the hazardous and one for the radioactive wastes. The storage room shall be large enough to provide for temporary storage of the hazardous waste and radioactive waste and room for storage of a specialized carts used to transport the hazardous waste from the laboratories. The hazardous waste storage segment shall be at least 2.5 m by 3.5 m. The radioactive waste storage segment shall be at least 0.75 m by 1.5 m. Facilities which generate larger amounts of hazardous or radioactive waste will need larger spaces.

There shall be at least three 2 m high storage cabinets in each room to provide segregated storage of incompatible materials. There shall be sufficient open floor space in the storage room to accommodate one 1 m long waste cart, while allowing a person to access the storage cabinets and shelving.

The storage room shall be designed to contain any spills of hazardous waste that may occur due to handling or mishandling of the waste materials. The waste materials will normally be transported using specialized carts which will provide spill containment. The designer may propose alternate means for spill containment within the storage room. Options may include a spill containment curb around the room and shelving or bins designed to contain spilled materials. A chemical-resistant coating shall be applied to the walls and floor in this area to make it easier to clean up spills.

The storage room shall be located near the loading dock for easy access to the trucks that will be used to transport the waste to Building 21 for processing. Personnel shall be prohibited from any processing of the hazardous wastes, such as bulking or lab packing, in this storage room.

There shall be convenient access from the storage room to the freight elevator without having to traverse heavily traveled

corridors. This will allow the contractor collecting the waste to bring the waste down from the laboratories to the storage room while minimizing the risks to the building occupants.

A separate ventilation system shall be installed for the storage room. This ventilation system shall be connected to the building's emergency power system. Standard illumination requirements exist for this room. The room shall be designed to fire protection Hazard Group 2.

Safety equipment shall be provided for each storage room. This safety equipment shall consist of a first aid kit, emergency eyewash, and emergency shower.

The NIH Division of Safety shall review and provide final approval of the design of all hazardous waste storage rooms.

Hospital Modules: All modules contained in the hospital buildings shall be designed for the safe storage of hazardous waste generated by the work activities. The volume of hazardous waste generated by a module is a function of the type of work being performed. Thus, the Designer needs to consider the function of the module to determine the space necessary for hazardous waste storage. Some hospital modules, such as the patient care areas, will not require hazardous waste storage. For those modules which do require hazardous waste storage, a minimum 0.75 m by 0.75 m area will be required.

The Designer must also recognize that some types of hazardous waste may be incompatible with other types and design the hazardous waste storage area to accommodate multiple containers. The Designer shall investigate the possibility of stacked containers that will provide sufficient storage space while minimizing the footprint in the module. Each storage container shall be designed to provide secondary containment of the hazardous wastes. The location of the hazardous waste storage area shall be standardized to assist emergency response personnel.

The hazardous waste storage area shall have at least two distinct segments to allow segregation of incompatible materials. Some modules may require three segments depending upon the types of hazardous waste that will be generated. Each segment of the

storage area shall be designed to contain a spill of at least 1gallon of hazardous waste. The configuration of the storage area shall be designed to facilitate spill cleanup. Interior surfaces of the storage area shall be cleanable, corrosion resistant, and nonreactive.

D.11.4 Bulk Storage Facilities

Above-Ground Storage Tanks: Wherever possible, the Designer shall consider the use of clean-burning fuels such as natural gas or liquid propane. If storage of these fuels is required, for example a day tank to ensure uninterrupted availability of fuel, it shall be in above-ground storage tanks installed in accordance with State of Maryland and Montgomery County, Maryland, requirements.

All above-ground storage tanks shall be double walled, be provided with secondary spill containment, and meet the requirements of the American Petroleum Institute and the National Fire Protection Association (NFPA). The tanks shall also be consistent with the NIH Spill Prevention, Control, and Countermeasures Plan.

Design considerations regarding the above-ground storage tanks include the location of the tanks to provide access for delivery trucks. At the same time, the tanks should be sufficiently isolated and protected from traffic flow to minimize the risk of accident. The tanks should also be placed in a location to minimize the aesthetic impact of the tank on the surroundings. This would include the use of berms and landscaping to block the view of the tanks.

Spill Control: All bulk storage facilities and above-ground storage tanks shall be equipped with secondary containment to prevent discharge of the material in the event of a spill or a leak. For single storage tanks, the secondary containment shall be large enough to contain the volume of the tank and rainfall from the 10-year, 24-hour storm. For multiple storage tanks, the secondary containment shall be large enough to contain the volume of the largest tank and rainfall from the 10-year, 24-hour storm.

Materials used to provide the secondary containment shall be impervious to the substance contained in the storage tank. The containments shall be equipped with a normally closed valve to

prevent accidental discharge of the substance from the containment. This valve can be manually opened to discharge accumulated rainwater after it has been determined that the water is not contaminated.

The other potential spill areas for hazardous substances on the campus are the loading docks. Spills can occur at the loading docks during the loading and unloading of hazardous substances or hazardous wastes.

Loading docks shall be designed to contain spills of hazardous substances and minimize the contamination of stormwater runoff. One option that would accomplish this objective would consist of a loading dock with a grate drain at the base that would accumulate any spilled substances. This drain would be equipped with a normally closed valve to prevent accidental discharge of spilled substances. Uncontaminated runoff would be diverted from this drain by a second grate drain and a small berm. An overhang would divert direct rainfall from the base of the loading dock to the uncontaminated runoff drain. Alternative designs which meet this objective may be proposed by the Designer.

Control of stormwater runoff and water quality around the NIH campus are discussed in the Reference Materials, Section G, Site/ Civil. To ensure proper water quality all drainage systems which collect runoff from the parking areas shall be equipped with oil water separators.

D.11.5 Wastewater

Wastewater Discharge: Only uncontaminated stormwater runoff shall be discharged from the NIH campus to the receiving stream. All wastewaters generated on the NIH campus shall be discharged to the sanitary sewer. Wastewaters generated on the NIH campus include domestic sewage from the lavatory facilities, non-hazardous waste discharged from research area sinks, waters used for cage washing and animal care, waters used in cafeteria operations, and all floor drains.

Wastewater Sampling: The NIH campus is connected to the WSSC sanitary sewer system. The NIH is permitted to discharge wastewater to the WSSC system through a Discharge

Authorization Permit. Under the terms of this permit, the NIH must sample its wastewater four times every 6 months and submit an Industrial User Effluent Compliance Permit report to WSSC twice per year.

The wastewater sampling is conducted at the two locations where the NIH sewers connect to the WSSC system. However, for new hospital facility construction, the sanitary system shall be designed to allow for sampling at the discharge point from the individual building. This will allow for testing and troubleshooting of individual building wastewater streams. The sampling point shall be designed to allow for installation of a continuous pH monitor, installation of a programmable sampler, and personnel access for grab sampling.

D.11.6 Wastewater Treatment

Since the NIH utilizes the WSSC system, it is normally not necessary to perform wastewater treatment on campus. However, it may be necessary to provide neutralization and equalization of wastewater streams from some hospital buildings to comply with WSSC requirements.

To allow for these circumstances, the sanitary system for new hospital buildings shall be designed with sufficient hydraulic gradient that an equalization or neutralization tank can be installed at a later date without a redesign of the sewer system or the installation of a pump station.

Tanks used for equalization and neutralization of wastewaters can accumulate sludges and hazardous wastes, require maintenance, and cause odor problems. Therefore, equalization and neutralization tanks will not automatically be installed in new construction. The Designer shall investigate the potential use of the building and attempt to characterize the potential wastewater stream based upon this proposed use. Equalization and neutralization tanks shall be included in new construction if the anticipated characteristics of the wastewater stream indicate that these facilities are likely to be required.

Any facility being designed with darkrooms or photoprocessing facilities shall have a processing facility for recovering silver from

the wastewater stream from the photoprocessing rooms.

D.11.7 Solid Waste

Waste Minimization: All hospital facilities at the NIH shall adhere to the Environmental Protection Agency's solid waste management hierarchy, which encourages reduction of waste at the source. This hierarchy emphasizes waste minimization as the first step in sound solid waste management. The utilization of reusable products, which also has the effect of reducing the overall solid waste stream, is also encouraged. Waste products that can not be reused should be investigated to determine if they can be recycled. Only those products that can not be reused or recycled should enter the waste stream for energy recovery or landfilling.

In general, solid waste management is an operational function. However, the requirements for environmentally friendly solid waste management must be included in the design of new construction in order for the solid waste management system to be efficient and convenient to use. Ease and convenience are keys to implementation of a successful solid waste management program.

One design feature that can assist in waste minimization in hospital modules is hazardous substance storage capacity. The Designer shall closely examine the anticipated use of the module to determine a reasonable volume of hazardous substances that should be stored in the module to allow efficient operations. Excessive storage space in a module can result in overpurchasing and hoarding of hazardous substances. This, in turn, can result in excessive hazardous waste generation as these substances are stored beyond their shelf lives.

Recycling: The NIH campus has an active solid waste recycling program. The program is administered by the NIH Office of Research Services (ORS). This program is described in the draft NIH document *Recycapable Blueprint for NIH*, dated March 4, 1995. This program establishes white office paper, baled corrugated cartons (OCC), aluminum cans, and polypropylene as primary recycling materials. Mixed paper, wood pallets, scrap metal, polystyrene, food and beverage containers, and yard waste are designated as secondary recyclable materials.

All new construction on the NIH campus shall be designed to be recycling friendly. This consists of placing recyclable collection containers at convenient locations throughout the building to make it easy for NIH employees to accumulate recyclable materials. The selection of recyclable to be collected; the type, size, and number of collection containers; and the locations for the collection containers must be selected by the Designer based upon the planned use of the new facility. For example, more emphasis would be placed on collecting white office paper in an office building than an animal care facility. The Designer shall coordinate this selection with the ORS, Division of Safety, Environmental Protection Branch.

Support facilities for recycling must also be included in all new construction. These support facilities would include space in the loading dock for storage of recyclable materials. Paper products, particularly white paper and OCC, must be kept clean and dry to maintain market value. These require either a room for storage or an enclosed container. Sufficient container space will also be required for the other recyclable materials. Multicompartment recycling roll-off containers are commercially available and may be used for recyclable storage and transportation.

The Designer may want to consider installation of a baler at facilities which are expected to generate sufficient amounts of OCC. A can flattener should be considered for any facility expected to generate sufficient aluminum cans.

The selection of the recycling support facilities and equipment required for all new construction shall be made by the Designer in coordination with the ORS, Division of Safety, Environmental Protection Branch. Potential options for the loading dock design have been developed by the ORS, Division of Safety, Environmental Protection Branch, and can be used as guidelines by the Designer.

Hazardous Waste: All hazardous waste generated on the NIH campus shall be handled in accordance with NIH's generator and TSD permits. Generally, this requires accumulation of the waste at the generation point, temporary (1 day or less) staging at the building loading dock, and transportation to Building 21 for processing. Any facility which cannot meet this format shall be

considered a special exception to these guidelines. The Designer shall develop the solid and hazardous waste design for this building in consultation with the ORS, Division of Safety.

Medical Pathological Waste: MPW is regulated by the State of Maryland. In the design of hospital facilities, both patient care and laboratory space, consideration must be given to the short-term storage of MPW. Architects/Engineers must review, with appropriate NIH personnel, the MPW generation in various areas of the hospital and design adequate storage space to accommodate quantities of waste expected over the time required to collect and remove the waste for transport and disposal.

Demolition:

Site Assessments: Prior to the demolition of any facility on the campus, the designer shall have a site assessment performed by a qualified environmental engineer. The purpose of the site assessment will be to identify any environmental site hazards that could result in the release of hazardous substances during the demolition or new construction. Potential hazards that must be addressed include possible asbestos-containing building material (ACBM), lead paint, underground storage tanks, hazardous substance storage areas, and spills of hazardous substances.

This site assessment shall include a review of records regarding the design, construction, and use of the building to be demolished and the site; a review of records regarding responses to hazardous substances pill incidents or other emergencies; visual inspection of the building and site; and sampling and analysis of subject materials are areas to provide quantitative data to backup the qualitative assessment.

Recycling of Demolition Debris: Prior to mobilization on the site, the demolition contractor shall be required to submit to the ORS, the Division of Safety, a waste disposal and recycling plan for the demolition activity. This plan shall identify each type of waste material that will be generated by the demolition. The wastes shall be classified as hazardous waste, general waste, or recyclable waste. The alternatives for disposal or recycling of each type of waste material shall be discussed in the plan, with the objective of recycling as much of the demolition materials as possible. For any material that will not be recycled, the contractor shall be required to document in the plan, to the satisfaction of the ORS, Division of Safety, why recycling is not feasible. During the demolition activities the contractor shall be required, on a monthly basis, to

report to the ORS, Division of Safety, on the status of the recycling activities. This will include weigh teckets or other forms of proof that the specified materials have been recycled. Payments to the contractor shall not be approved unless this documentation has been provided and the contractor is performing in accordance with the approved waste management and recycling plan.

The contractor shall also be responsible for completing and delivering to the Division of Safety, Environmental Protection Branch, of the following forms:

- Contract Recycled Material Notification Form
- Exempt Recyclable Material Manifest
- Nonhazardous Recyclable Material Manifest

Copies of these forms are attached.

Any wastes generated during the demolition that are designated as hazardous wastes or that require special waste-handling procedures (e.g., asbestos waste) shall be properly handled, transported, and disposed of by the demolition contractor. All manifests, certificates of disposal, and other documentation of proper handling and disposal shall be provided to the ORS, Division of Safety.

Contract Recycled Material Notification Form

Project Title	
Location of Project	
Contact Number	
NIH Project Officer (Name and Phone)	
NIH Contract Officer (Name and Phone)	
Name of Contractor (Company, Contact Person Name and Phone)	
Sub Contractor (Attach List If Necessary)	
Types of Materials Anticipated To Be Recycled: (Building materials includes items intended for reuse, provide description of other.)	___Ferrous Scrap Metal ___Nonferrous Scrap Metal ___Concrete/Asphalt ___Glass ___Insulation ___Plastics ___Building Materials ___Electrical Wire/Cables ___Wood ___Other

The above information should be forwarded to the NIH Division of Safety, Environmental Protection Branch (EPB), (Bldg. 13/Rm 2w64, NIH) if recycle able material will be removed under this contract. A recycle able material manifest, either nonhazardous or exempt shall be prepared for each shipment of recyclable materials. Any manifest for shipment of exempt hazardous materials (e.g. scrap metal with lead paint) should be forwarded to the EPB, 3 days prior to shipment for approval and will be signed by an EPB representative on the shipping day. The contractor shall forward to EPB, completed copies of all shipping documents together with weight tickets signed and dated by the contractor in verification of their accuracy within 30 days of the shipping date.

The exempt Recyclable Material Manifest will be used for scrap metal which contains hazardous waste, constitutes as an inherent component or external coating, but is still acceptable to a recycle outlet.

The Nonhazardous Recyclable Material Manifest will be used for any nonhazardous waste which is being recycled and is **not** scrap metal and is acceptable at a recycling facility must be shipped as hazardous waste using a hazardous waste manifest signed and approved by the EPB.

Name_____

Signature_____ Date _____

DES/NIH Project Officer

Name; _____

Signature: _____ Date _____

DES/Contractor Contact Person

Name: _____

Signature: _____ Date _____

Revised 10/26/95 Chief, Environmental Protection Branch Representative

Revised 10/26/95 Manifest No. _____

EXEMPT RECYCLABLE MATERIAL MANIFEST

Generator Name_____
Address:_____
_____
Phone No._(_____)_____

Generating Location:_____
Address:_____
_____
Phone No._____

	Description of Waste	Net Weight	Units
Container Type	_____	_____	____
	_____	_____	____
	_____	_____	____
	_____	_____	____
Container Type	_____	_____	____
	_____	_____	____
	_____	_____	____
	_____	_____	____
Container Type	_____	_____	____
	_____	_____	____
	_____	_____	____
	_____	_____	____

It is certified that the scrap metal described above is a recycle able material as defined in Title 40 CFR 261.6 (a)(1) and COMAR 26.13.02.06. This shipment to a facility for reclamation does not require a Uniform Hazardous Waste Manifest, disposal at an EPA-or-State permitted facility, or compliance with other hazardous waste requirement for Title 40 CFR 262-266 or Parts 268-270 or 124 and Maryland State Regulation COMAR 26.13.03.07. This material has been properly described, classified and packaged and is in proper condition for transportation according to regulations.

_____ _____
Generator Name (NIH Representative) Signature Shipping Date

Truck/ Container No._____ Phone No. _____
Transport Co. _____

Driver Name:_____
Address: _____
_____
Vehicle Licence # _____
Vehicle Certification; _____

I hereby certify that the above named material was picked up at the generating site listed above.

I hereby certify that the named material was delivered without incident to the destination listed below.

_____ _____
Signature Ship Date Signature Delivery Date

Site Name:_____
Phone No.: _____

EPA Generator ID No. (If waste is not inherently hazardous.)_____
Address: _____
_____
Comments:
_____
_____
_____
_____

I hereby certify that the above named material has been accepted and to the best of my knowledge the foregoing is true and accurate.

_____ _____ _____
Recycling Facility Representative Signature Shipping Date

RECYCLING FACILITY: Please attach a copy of the weight ticket to a copy of this manifest and return to the Generator at the above address.

Revised 10/26/95
Manifest No._____

NONHAZARDOUS RECYCLABLE MATERIAL MAIFEST

Generator Name_____
Address:_____
_____
Phone No._(_____)_____

Generating Location:_____
Address:_____
_____
Phone No._____

Description of Waste	Net weight	Units	Container Type
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
	_____	_____	_____

It is certified that the material described above does not contain free liquid as defined by 40 CFR Part 260.10 or any applicable State law and is not a hazardous waste as defined by 40 CFR Part 261 or any applicable State law. This material has been properly described, classified, and packaged and is proper condition for transportation according to applicable regulations.

_____ _____
Generator Name (NIH Representative) Signature Shipping Date

Truck/ Container No._____ Phone No. _____
Transport Co. _____

Driver Name:_____
Address: _____
_____
Vehicle Licence # _____
Vehicle Certification; _____

I hereby certify that the above named material was picked up at the generating site listed above.

I hereby certify that the named material was delivered without incident to the destination listed below.

Comments:_____

_____ _____
Signature Ship Date Signature Delivery Date

DESTINATION

Site Name:_____
Phone No.: _____

Address: _____
_____
Comments:
_____
_____
_____
_____

I hereby certify that the above named material has been accepted and to the best of my knowledge the foregoing is true and accurate.

_____ _____ _____
Recycling Facility Representative Signature Shipping Date

RECYCLING FACILITY: Please attach a copy of the weight ticket to a copy of this manifest and return to the Generator at the above address.

D.12 Fire Safety/Fire Protection

This fire protection section includes specific requirements for Hospital Facilities. The general fire protection requirements are found in Section H - Reference Materials.

Contract Drawings: The cover sheet of the contract drawings and Specifications for projects involving the upgrade of existing Patient Care Units associated with Mental Health Care shall be clearly labeled "Mental Health Care".

D.12.1 Fire Resistant Materials and Construction

Smoke Barriers: All corridor walls in health care occupancies (as defined by NFPA 101) shall be smoke tight from slab to slab. Smoke dampers are not required. In existing heath care occupancies where corridor wall construction cannot be continuous from slab to slab (ie. the wall ends just above the suspended ceiling), a 2.54 cm thick cementious fire proofing material shall be sprayed on wire lath that is anchored to the wall and floor slab above. (Note: This alternate barrier design cannot be used for the fire rated barriers described below.)

One Hour Barrier: The following areas, and any others which have been designated as High Hazard areas by the NIH Fire Prevention Section, shall be protected with one hour construction , as well as any other protection required in accordance with NFPA 101, Chapter 12. The door openings in these fire rated walls or partitions shall be protected with 3/4 hour, C label, self-closing fire door assemblies. Specific separation requirements include:

- Soiled Utility/Soiled Linen Rooms and Dumbwaiter Rooms shall be separated by one hour fire rated construction.

- Clean Utility/Clean Linen Rooms and Storage Rooms shall be separated by one hour fire rated construction if the area is greater than or equal to 9.3 square meters.

Two Hour Barrier: The health care occupancy shall be separated from non-health care areas by two hour fire resistive construction. The door openings in these fire rated walls or partitions shall be

protected with 1.5 hour, B label self-closing fire door assemblies.

Automatic Sprinkler Systems: All sprinkler system designs shall meet, at a minimum, NFPA 13 Ordinary Group I spacing and hydraulic requirements. All areas within health care occupancies shall be sprinkler protected.

Sprinklers in the vicinity of mental health care areas are to be the institutional quick response type, with a 71°C to 74°C temperature rating.

Sprinklers in the patient rooms, patient treatment rooms, toilet rooms, offices, and corridors shall be quick response heads with a 71 to 74°C temperature rating.

Fire Protective Signaling Systems: An addressable multiplex fire alarm system shall be provided for health care occupancies.

All health care occupancies shall be equipped with ionization type smoke detection in the following areas:

- Patient care corridors
- Patient treatment or examination rooms
- Patient sleeping rooms

The electromagnetic door strikes for the 1.5 hour, B label fire doors located at each end of a Patient Care Unit (PCU) shall be interfaced with the fire alarm system such that upon activation of the fire alarm system, the doors are **"fail safe"** (available for egress) on the PCU side of the door and are **"fail secure"** (will NOT permit access without use of a key) from outside the PCU.

Duct Smoke Detection: Duct smoke detectors shall be installed in accordance with the requirements of NFPA 90A. Duct smoke detectors shall be of the photoelectric type, connected to the building fire alarm system, and cause shutdown of the associated air handler upon alarm.

Fire Extinguishers: Fire extinguishers shall have fully recessed cabinets, with the upper edge at 1.37 meters above the finished

floor. All fire extinguisher cabinets shall be sized to contain a 9.6 liter pressurized water extinguisher. (Type 2)

Hospital fire extinguishers shall be located in the corridors. The maximum travel distance to an extinguisher cabinet, from any point, shall be 23 meters.

A fire extinguisher cabinet shall be provided at each nurses station.

Fire extinguishers shall be located only at the nurses station in the mental health facilities.

D.13 Pest Management

Patients and personnel are at risk to infections carried by pests and vermin. Nosocomial infections in immunocompromised patients have been traced to the roosting of birds on window sills and in air intake vents. The Architect/ Engineer must consult with the, the NIH Division of Safety, Pest Management Unit to ensure appropriate pest managment requirements.

Consideration of pest management should be given to all functions, finishes, or details contributing to infestation in or around the building. Design features should promote cleaning, maintenance, and better storage while minimizing pest access.

The only effective pest control program is strict prevention of infestations. Above all else maintaining a clean, sanitary facility at all times will minimize food sources and breeding areas for most vermin.

All penetrations, cracks, voids, and gaps in room enclosures should be sealed and caulked. The hospital must also be made secure from external pests via introduction of barriers at entries and exits (air curtains, vestibules, etc.)

Exterior windowsills should be avoided to discourage bird nesting or roosting.

The Architect/Engineer should ensure that areas of pest ingress, such as doors, windows, loading docks, etc., are fitted with appropriate exclusion devices. Consideration should also be given to designs that minimize creation of pest harborage and promote proper cleaning. Examples of harborages are inaccessible voids behind and under equipment and casework, unsealable cracks or joints between equipment of finish materials, or the use of unsealed foam or fiberglass insulation on pipes and equipment.

The NIH Division of Safety, Pest Management Unit, should be consulted to review and approve all plans for new construction and renovation of old space.