Electrical

Reference Materials
NIH Design Policy and Guidelines

The following design policies and guidelines shall apply to all systems within the electrical engineering discipline. The purpose is to provide uniformity of design based on the established NIH Design Policy and Guidelines.

E.1 General Building Guidelines and Design Considerations

E.1.1 Calculations

Each electrical design shall include the submittal of the following design calculations:

- Lighting calculations showing required and designed lux.
- Estimated panelboard loading (including 25% extra as a projection of future building loads)
- A projection/summation of the panelboard loads to justify the sizing of the network transformers
- An economic analysis to justify the selection of either 120V/208V or 277Y/480V on the secondary side of the network transformers
- An analysis, for the 277Y/480 V choice, as to whether the stepdown transformer(s) shall be large central units or smaller units placed throughout the building
- A short-circuit analysis to determine the AIC rating of the system components.
- A coordination study to determine the circuit breaker settings and system coordination.

E.1.2 Design

The design documents shall be presented for review at various stages of completion as determined by the Project Officer. The comments returned from the NIH reviewers shall be given careful consideration, as these are based on experiences with past designs that have caused problems for the research or the maintenance personnel. Provide written responses to these comments.

E.1.3 Design Analysis Narrative

Where the design is of an unusual nature, and the intent is not readily discernible, a separate design analysis narrative shall be prepared to explain the intent and reasoning behind the novel design. This shall be presented in the earlier stages of review to offset the possibility that the design might not be suitable to NIH personnel.

E.1.4 Maintenance and Operational Manuals

Operation and repair manuals for all electrical equipment supplied on the project are required and shall be called for in the specifications. A meeting shall be specified to turnover the equipment inventory and O&M manuals to Maintenance Engineering Section.

E.1.5 Panel Schedules

The information to be supplied on the panelboard schedules is all data necessary to order the equipment and all data needed to completely identify the attached loads. Information to be clearly shown shall include the following:

- Panel name
- Number and size of spare breakers
- Number of bused spaces and the maximum ampere ratings
- Total number of breaker positions in the panel
- Top feed or bottom feed
- Main circuit breaker (MCB) or main lugs only (MLO)
- Surface or recessed mounting
- Trip rating, frame rating, and number of poles of each breaker
- The AIC rating of the panel; series rating is not acceptable
- The identification of the load and the room name
- The estimated connected load in watts
- The estimated connected load in volt amperes (orKVA) per circuit
- Panel total connected KVA and Amps
- Panel total demand KVA and Amps

E.1.6 Reference Design and Safety Guidelines for the Electrical Designer

The NIH is a progressive and dynamic biomedical research institution where state-of-the-art medical research is the standard practice. To support state-of-the-art research and medical care, the facilities must also be state-of-the-art. Therefore, it is the intent to build and maintain the electrical systems and facilities in accordance with the latest standards.

It has been the NIH experience that the renovation and rehabilitation of existing facilities do not always lend themselves to incorporating the "latest" standards of the industry. Some of the existing electrical systems are outdated or inadequate for the new load. Often the planned function is incompatible with the original criteria for the building.

The A/E shall be alerted to this type of situation and make an evaluation early in the design stage to determine the implementation feasibility of the latest standards. The A/E shall document such findings, provide recommendations, and report them to the Project Officer for a decision on how to proceed.

The A/E design firm shall use and comply with, as a minimum, the latest issue of the following design and safety guidelines. In addition, the A/E shall use other safety guidelines received from the NIH Project Officer or as required by the program. The A/E shall utilize the latest versions of guidelines available at the time the project proceeds with schematic design.

The reference codes, regulations, and recommended practices include but are not limited to the latest version following:

- Association of Edison Illuminating Companies (AEIC)

- American Hospital Association (AHA), Management and Compliance Series, *Electrical Systems for Health Care Facilities*

- American National Standards Institute (ANSI)

- AHA, Management and Compliance Series, *Fire Warning* *and Safety Systems*

- American Society of Mechanical Engineers (ASME) A17.1: *Safety Code for Elevators and Escalators*
- American Institute of Architects (AIA), *Guidelines for Construction and Equipment of Hospitals and Medical Facilities*
- Building Officials and Code Administrators, International (BOCA) *The BOCA National Building Code*
- Electronic Industries Association (EIA)
- International Cable Engineers Association (ICEA)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE), color books
- Illuminating Engineering Society of North America (IESNA), *Lighting Handbook*
- Lightning Protection Institute, LPI 175 Standard of Practice
- National Electrical Code (NEC), National Fire Protection Association NFPA Standard 70
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC) IEEE C2
- International Electrical Testing Association (NETA), *Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems*
- NFPA, National Fire Codes (NFC)
- NIH, Design Policy and Guidelines
- NIH 86-23, *The Guide for the Care and Use of Laboratory*

Animals

- Telecommunications Industries Association (TIA)
- Uniform Federal Accessibility Standards (UFAS)
- Underwriters Laboratories (UL)

E.2 Energy Conservation

E.2.1 Electronic Ballasts

Electronic ballasts shall be used in 600 mm, 1200 mm, and 2450 mm long fluorescent lighting fixtures. See the Lighting section for ballast specifications.

E.2.2 Fluorescent Lamps

Fluorescent lighting fixtures 600 mm x 600 mm, 600 mm x 1200 mm or 2450 mm long shall use T8 (25 mm diameter) lamps. The ballast/lamp combination shall have an efficacy in excess of 80 lumens per watt (LPW).

E.2.3 Programmable Lighting Control (PLC)

The use of relays to control lighting circuits or subcircuits with a programmable controller is encouraged from an energy conservation standpoint. The system must be flexible and easy to use. There shall be a warning of an impending off cycle to allow occupants the opportunity to dial an override command on the telephone or press an override switch.

Corridors are a good application for PLCs with local override switches or occupancy sensors to control a minimal amount of corridor lighting.

E.2.4 Occupancy Sensors

Occupancy sensors work well in conference rooms, bathrooms, and single-person offices. The ultrasonic-type sensors shall be utilized in enclosed rooms such as bathrooms and conference rooms. The passive infrared-type sensors shall be utilized in single offices. The ceiling-mounted, ultrasonic and switch replacement, passive infrared units shall be specified depending on the room configuration. The designer shall check with the manufacturer for recommendations. Where fluorescent lighting fixtures are controlled by occupancy sensors, they shall have rapid-start electronic ballasts.

E.2.5 Lighting Control

Localized switching shall be provided in lieu of large-area switching. Labs shall be switched in 3.4 m width groups within a multi-modules.

E.2.6 Multilevel Switching

Dual switching shall be provided where appropriate with three-lamp fluorescent light fixtures. The fixtures shall have two ballasts, one for the inner lamp, one for the outer lamps. One switch controls each ballast, providing the flexibility of one, two, or three lamps to be lighted.

E.2.7 Environment Protection Agency Greenlights Program

The Greenlights program has a lot of good recommendations for energy savings through lighting. The Greenlights program requires an economic analysis of the energy-saving options to determine on a life cycle cost basis which options are viable. The Greenlights program not only makes recommendations primarily for retrofit of existing lighting, but also for new installations.

E.2.8 Day Lighting

Spaces within buildings with large amounts of exterior glass or skylights shall utilize photocell control of electric lighting. Lobbies as well as exterior offices are good examples of daylighting opportunities. Adjustable photocells must be the overriding control to allow for cloud cover and twilight. Zoning the lighting in rows of fixtures parallel to the exterior wall is preferred. Dimming of fluorescent fixtures in response to a photocell is also a way of saving energy.

E.2.9 Exit Signs

Light emitting diode type exit signs shall be used at the NIH.
Exit Signs shall have a minimum 10 year warranty.

E.2.10 High-Efficiency Motors

High-efficiency motors are specified in section D, Mechanical.

E.2.11 Metering

Metering of the building's electrical service is essential for monitoring energy consumption and taking an active role in energy conservation. Section E.4, Normal Power section describes electrical metering requirements.

E.2.12 Rebates

The Potomac Electric Power Company (PEPCO) provides power to the NIH Bethesda, MD, campus. PEPCO is offering rebates or incentives for retrofitting or new installations as of this writing. Rebates are given for fluorescent F-32 T8 lamps and electronic ballasts meeting PEPCO requirements. Rebates are also given for other energy-efficient lighting. The rebate program must be verified with PEPCO, telephone 202-872-4630. The PEPCO rebate program is only for Maryland.

E.3 Economic Analysis

Whenever an economic analysis is required, it shall be performed similar to that described in section D, Mechanical. An economic analysis shall be performed when a clear choice is not apparent between two or more possibilities. When there are two choices, the simple payback method can be used. Three or more choices requires the present-worth analysis method.

E.4 Normal Power

E.4.1 New Service Connection

The NIH will determine the most appropriate location for a service connection to the primary voltage (13.8 kV) system on the Bethesda campus. The service connection may be made by tapping to an existing feeder in a manhole or by adding a second pothead to an existing service in a nearby building. The service may require a new feeder from the nearest 15 kV substation.

E.4.2 Standard Cable Size and Type

The NIH has standardized on PILC (paper insulated, lead covered) cable, with an outer jacket of either neoprene or polyethylene. The PILC feeders on the NIH campus have been in service longer than some of the newer types have been manufactured. The PILC cable lasts more than 50 years. The NIH, to be prudent, is starting a program to replace some of the cable that is older than 50 years, but it will be replaced with the same type as long as PILC cable is available. Wherever new feeders must be spliced into existing PILC cable, PILC cable shall be provided.

The NIH has standardized on 500 thousand circular mils (MCM) as the preferred size for the 15 kV cable; however, most of the existing cable is 350 MCM. The system voltage is a nominal 13.8 kV, and the NIH system is operated underground. The cable is compact-sector, 100% insulation, shielded, with the lead sheath grounded in each manhole. Splices shall be custom made at each site by an experienced cable splicer using customized splicing kits from a reputable cable manufacturer. All splices shall be started and carried through to completion without interruption, usually taking about 8 hours.

The load carrying capability of 500 (or 350) MCM cable is much higher, at 13.8 kV, than is needed for most of the loads on the NIH campus. The 500 MCM size has been chosen as a standard size to simplify fault calculations and to reduce the amount of stock cable for replacement purposes. The large size allows for future expansion without replacing feeders.

The availability of PILC cable is becoming more restricted because demand is dropping. Manufacturers are reluctant to manufacture small quantities of PILC cable. They will hold orders until they have a sufficient quantity to justify manufacturing. The NIH has a limited stock of 500 (and 350) MCM PILC cable. The NIH will "lend" the contractor PILC cable if available to do certain replacement projects with the understanding that the replacement cable will be returned to the NIH when it is manufactured.

If, however, a completely new feeder is installed as part of the project from a 15 kV substation, then it may be ethylene propylene rubber (EPR)-insulated or PILC. EPR cable shall not be spliced to PILC cable.

The EPR cable shall be 500 MCM,15 kV single copper conductor, shielded 90^{o}C and rated with a 100% insulation level. The strand screen shall be extruded semiconducting EPR meeting or exceeding the electrical and physical requirements of ICEA S-68-516, AEIC CS6, and UL 1072. The shield shall be 5 mil thick bare copper tape helically applied with a 12-1/2% overlap. The jacket shall be a polyvinyl chloride (PVC) jacket. The cable shall be UL listed as Type MV-90 in accordance with UL 1072. Each feeder shall consist of three single-conductor cables, plus a ground wire as described hereinafter, or a three-conductor cable with an integral ground.

Where EPR cable is installed, it shall have a copper ground conductor installed with the phase conductors. The ground conductor shall be No. 1/0 AWG minimum in accordance with NEC Article 250-51 and Table 250-94.

E.4.3 Distribution Duct System (DDS)

The NIH has two underground duct and manhole systems; one is for electrical power cables and one is for communication circuits. The DDS for electrical power has the manholes designed with the letter "E" followed by a number (one to three digits). Where a duct line branches off an existing manhole, the new manhole will have a subletter designation. For example, the existing manhole is E-29, and two new manholes, E-29A and E-29B, are added on the same branch. The manhole designations for communications manholes will be discussed in section E, Local Area Network.

The ducts contain only high-voltage feeders, rated 15 kV for use on the NIH nominal 13.8 kV system, and supervisory cables which monitor and control the high-voltage system. The older supervisory cables, which are in the process of being replaced, were multiconductor control cables. Recently the NIH has begun a process of replacing these cables with smaller-diameter data links over fiberoptic paths in the existing campus local area network (LAN) cables and over telephone lines.

The area surrounding manholes in grass areas shall be regraded to drain away from the manhole cover. Manhole covers shall be 13 mm above finish grade. Manholes shall be provided with a sump approximately 300 mm x 300 mm x 150 mm deep. Preferable manhole locations shall be in grass areas first, sidewalks second, and in the street last. Manholes shall not be located in parking spaces. Where ducts are sloped from a high to a low manhole, they shall be sealed at the high end only to allow condensation to drain. Cables in manholes shall be labeled with embossed brass cable tags and brass chains. Manholes shall be provided with two manhole covers, one for forced air and materials entry and the other for worker access. The standard manhole frame and cover shall be 700 mm in diameter (600 mm inside diameter). Manhole covers shall be labeled ELECTRIC for power and TELEPHONE for communications. The cover shall have a small, flat area for labeling with the manhole number by a welded bead. An embossed brass tag with the manhole number shall be permanently mounted inside the chimney and legible from outside the manhole with the cover removed.

E.4.4 Elevation Considerations

The DDS consists of multiple duct runs between manholes of 100 mm inside diameter PVC Schedule 40 ducts with a concrete encasement. The encasement has steel reinforcement in a plane just below the lowest row of ducts where the duct run spans disturbed earth, where it enters manholes and buildings (out to 1.8 m), and where it crosses under heavily traveled roadways. The spacing between ducts is 75 mm in all directions. The ducts shall be 760 mm minimum clear below grade or top of roadway.

Duct runs shall be sloped from the higher manhole entrance to the lower manhole entrance with no intermediate low spots that would pool moisture. If manhole entrance points are on about the same level, then there must be an arch in the duct run so that there is drainage from a high point into both manholes. If a low point is absolutely unavoidable, another manhole shall be provided at or near the low point.

E.4.5 Grounding

Each manhole shall be equipped with a 3 m long, 20 mm copper-clad steel ground rod through the floor of the manhole, with all metallic components in the manhole such as racks, cable sheaths, ladder, etc. securely grounded to this rod with a #6 AWG green insulated cable.

E.4.6 Maximum Length Between Manholes

The maximum cable length between manholes shall be kept to less than 120 m for an essentially straight run and reduced by 15 m for each bend of .79 Radians and by 30 m for each bend of 1.6 Radians. Bends shall be made with the largest radius possible. This by no means releases the engineer or the contractor from doing the necessary cable-pulling calculations to make sure the maximum tension or sidewall pressures are not exceeded.

E.4.7 Spare Capacity

When new duct runs and manholes are installed, additional ducts shall be provided for the future. There shall be at least two spare ducts included with the required ducts, more if this will round out a duct bank to a symmetrical configuration. Thus odd numbers of duct, such as 7, 11, or 13, shall not be constructed.

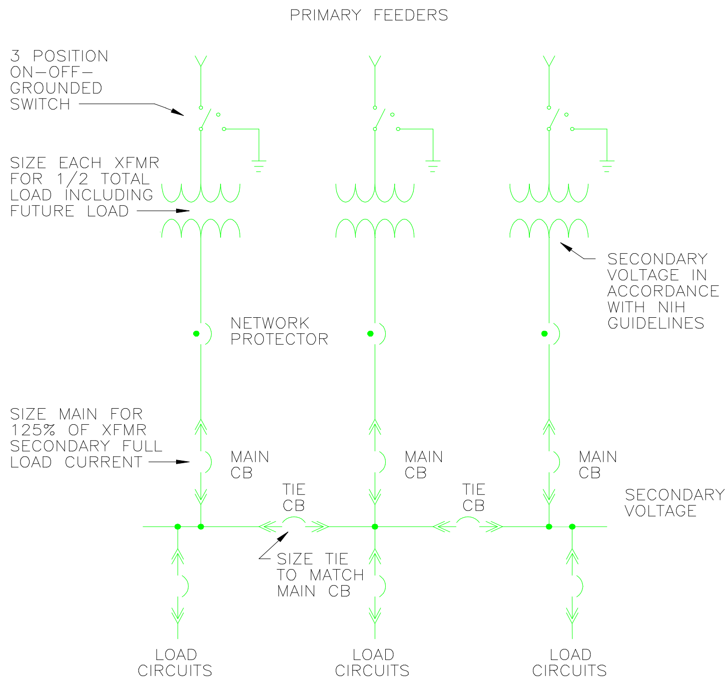
E.4.8 Normal Power

The following load figures in voltamperes per square meter (VA/m^2) shall be used in sizing the overall building service for an office building. For load figures on laboratories, vivariums, and hospitals, see the respective books. These figures are connected load and shall 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	32- 38
Receptacles	32- 48
Heating, ventilation, and air conditioning (HVAC)	54
Elevators	11
Miscellaneous	11
Total range	140-162

E.4.9 Network Transformers

The typical building service shall utilize a three-transformer spot network. Each transformer shall be sized for 50% of the total building load including any spare or future capacity. Building 10 has multiple services with both three and four transformer spot networks. See Diagram E-1.



SINGLE LINE DIAGRAM
TYPICAL BUILDING SERVICE
DIAGRAM E-1

Network transformers shall consist of a 15 kV primary switch, a silicone liquid-filled transformer, and a secondary network protector. The transformer manufacturer shall coordinate and be responsible for the entire unit (switch, transformer, and network protector). The network protector shall be of the draw-out type for ease of maintenance.

E.4.10 Location

The network transformers shall be located preferably indoors in a transformer vault. The alternate location is outdoors in a pad-mounted configuration. Network transformers shall not be located in underground vaults.

Network transformers located indoors shall preferably be in the same room (vault) as the secondary switchgear or in an adjacent transformer vault.

Pad-mounted network transformers shall be located outside the service entrance switchgear room. The secondary service conductors shall be kept as short as possible.

E.4.11 Removal Route

The size of network transformers and the requirements for power reliability at the NIH require that there be an exit route specified for these large, heavy items of electrical equipment. The designer of the building must provide for a permanent exit route to remove these large items and bring in new units. Note that the faulty unit must be removed while the other one (or two) or three transformers remain in place and in operation. The suggested method is to use painted stripes and warning signs on the floor and walls along the exit route.

E.4.12 Primary Switch

The 15 kV primary switch is a three-position, no-load break switch. The three positions are OPEN, CLOSED, and GROUND. The closed position is the center position. The switch is key interlocked with the transformer tap changer mechanism such that it must be in the ground position before the transformer-taps can be changed.

E.4.13 Transformer

Network transformers shall have temperature gauges with resettable maximum pointers, sampling valves, high-pressure release valves, and a key-interlocked tap changer. The tap changer shall have five settings, two above and two below the 100% rating. Each tap shall represent 2-1/2% of nominal voltage. Transformer windings shall be copper and full kVA rated.

E.4.14 Network Protector

The network protector shall contain time delays and other controls to prevent "pumping." Pumping is the cyclical opening and closing of the network protector.

Each network protector shall have a disconnect switch mounted on top of, or on the opposite wall from, the network protector. The disconnect is a maintenance isolation switch for working on the network protector. Disconnecting links are no longer allowed for safety reasons.

Spot networks shall include the installation of a Government-provided, contractor-installed remote terminal unit (RTU). The RTU is a multiplexing device that sends monitoring and control signals from the respective building to the existing campuswide SCADA system.

The RTU shall be located in either the transformer vault or the secondary switchgear room and requires a 120 V circuit. The output control voltage is 48 V DC. The network protectors shall have auxiliary relays with 48 V DC coils for shunt tripping by the RTU.

The RTU monitors the following devices/functions:

- Pressure and temperature of liquid-cooled network transformers
- Status of network protectors
- Status of all secondary main and tie circuit breakers
- Status of any battery bank systems in substations

The RTU controls the following devices:

- Tripping of network protectors
- Opening and closing of secondary main and tie breakers

The RTU has analog inputs to measure:

- All secondary switchboard metering

The RTU is provided with a number of analog and digital sensing points, as well as a number of relays for the control functions. The number of points can be augmented in the future as additional points are needed or defined.

E.4.15 Secondary Switchgear

Metal enclosed, low-voltage (below 600 V) power circuit breaker switchgear is defined by ANSI/IEEE Standard C37.20 as a metal enclosure containing power circuit breakers in a stationary or drawout configuration in individual grounded metal compartments controlled remotely or from the front of the enclosure. The air-power circuit breakers, fused or unfused, shall be in accordance with ANSI/IEEE Standard C37.13.

The internal switchgear busing shall be copper and shall be insulated with PVC or other tough insulating material, except at split connections and where cable connectors are located. At these locations removable boots shall be provided for inspection of connection points.

The electrical arrangement of the switchgear is shown in single line form in Diagram E-1. The switchgear shall have a main circuit breaker for each network protector. Each main circuit breaker shall serve a section of main bus. The sections shall be connected by tie breakers of the same ratings as the mains. The main and tie breakers are normally closed and electrically operated. The normally closed breakers form a spot network. The tie breakers will sectionalize the main bus should a fault occur, thereby minimizing the outage to one section of bus. The breakers are electrically operated to allow remote operation by the campus SCADA system.

Metering shall be provided on the load side of each main circuit breaker. Local digital readout is preferred; however, analog metering with switches is acceptable. The following minimum metering is required:

- Volts (phase to phase and phase to neutral)
- Frequency
- Ampere demand (per phase and average three-phase)
- Kilowatt hours (resettable)
- Kilowatt demand (three-phase)
- KVA demand (three-phase)
- Harmonic load content (percent THD)
- Power factor

The switchgear shall include the provision of a control power transformer associated with each switchgear section and the necessary switching logic so that there will be 120 V relay and control power if any one of the three network transformers is energized.

The breakers in the secondary switchgear shall be either drawout air circuit breakers or drawout vacuum circuit breakers. Molded-case circuit breakers are not allowed. Switchboard construction is not allowed. Each breaker shall have self-contained local digital metering with remote reporting capability. The following values shall be metered:

- Volts (phase to phase and phase to neutral)
- Amperes
- Kilowatt hours (resettable)
- Kilowatt demand
- Kilowatt peak demand

Each switchgear lineup shall have a hoist provided for lifting the circuit breakers from their withdrawn position and lowering them to a dolly or to the floor. A rail assembly shall be provided along the top of the switchgear with a hoist mechanism that can roll from end to end.

Spaces in switchgear shall be fully bused. Spaces shall have insulated covers over bus stabs and a complete drawout mechanism ready for breaker installation.

Switchgear shall be located in electrical rooms dedicated to such use. No piping, ducts, or equipment foreign to the electrical equipment shall be permitted to be installed in, enter, or pass through electrical rooms in accordance with NEC requirements.

Switchgear shall have the joints in the top (between sections) caulked with silicone after installation. Likewise, any conduit connections that are not inherently watertight shall be caulked.

Electrical equipment that requires specialized tools for installation, maintenance, calibration, or testing shall have such tools supplied with the associated equipment and turned over to the NIH Electric Shop at the end of the construction project. These tools can be as simple as a special screwdriver for vandal-proof lighting fixtures or the very complex test and calibration equipment needed to maintain solid-state circuit breakers. The argument that says tools are proprietary is not acceptable, and withholding the tools shall be cause for nonacceptance of the respective equipment.

E.4.16 Load Segregation

Wherever possible loads shall be segregated into like groups based on function or type of load. Examples of functions are laboratories, offices, health care, vivarium, etc. Examples of types of loads are computers, motors, lighting, receptacles, etc.

E.4.17 Work Space

The following clearances are required on new projects around secondary switchgear:

- 1,500 mm in front minimum
- 1,100 mm in rear minimum
- 900 mm on the ends minimum

Renovation projects shall have at least the code minimum clearances.

E.4.18 Voltage

The standard voltages on the NIH campus are:

- 13.8 kV — 3 phase, 3 wire — Primary voltage
- 4,160/2,400 V — 3 phase, 4 wire — Large motor voltage, power plant only
- 480/277 V — 3 phase, 4 wire — Preferred secondary voltage
- 208/120 V — 3 phase, 4 wire — Optional secondary service voltage and receptacle and 120 V utilization voltage

The secondary service voltage selection shall be based on load. The preferred voltage is 480/277 V. Typically a building load of 750 KVA or less could operate on 208/120 V unless there are compelling reasons to use 480/277 V. An economic analysis shall be performed to determined the best choice of voltage rating where the decision is unclear.

If 480/277 V is the chosen voltage, then a decision must be made where the transformation is to occur for 208/120 V loads: either at centrally located transformers or dispersed smaller transformers close to the load. An economic analysis shall be performed where the choice is not clear.

E.4.19 Fire Pump

A fire pump, if required, shall be connected to the secondary switchgear with a feeder breaker. The feeder breaker shall be sized to carry the fire pump locked rotor current. The mains and ties for the switchgear shall be sized to carry the maximum building demand each breaker will carry plus the fire pump locked-rotor current. The feeder shall be routed outside the building per the NEC requirements.

E.4.20 Elevators

All automatic (nonattendant) elevators having a travel of 7.62 m or more shall conform to the latest ASME/ANSI Standard A17.1 Elevator Code. The NIH defines two modes of emergency elevator operation, Phase I elevator recall and Phase II In-car operation.

- A three-position (OFF, ON, and BYPASS) key-operated switch for Phase I emergency recall operation shall be provided only at the designated level for each single elevator or for each group of elevators. The key shall be removable in the OFF and ON positions only. The switch shall normally be in the OFF (nonoverride) position. Operation of the three positions shall be as follows:

  OFF position: Restoration of normal elevator service to the elevator or group of elevators served by the switch.

  ON position: Recall of the elevator or group of elevators served by the switch to the designated level.

  BYPASS position: Allows the restoration of normal elevator service to all elevators served by the switch when a lobby smoke detector is malfunctioning.

- Smoke detectors shall be installed in each elevator lobby and in the associated machine room(s).

- The activation of a smoke detector in any elevator lobby, other than at the designated level, or in any associated machine room shall cause all cars in the group to return nonstop to the designated level in conformance with the requirements of ASME/ANSI Standard A17.1.

- If the smoke detector at the designated level is activated, the operation shall conform to the requirements of ASME/ANSI Standard A17.1, except that the cars shall return to an alternate level approved by the NIH Division of Safety, Fire Prevention section.

- If the firemen's override switch is in the ON position, the above described automatic operation shall be defeated.

- The contractor shall provide Phase I emergency recall operation and Phase II emergency in-car operation key switches which come with the installation of the elevators for use during construction. After complete installation and before final acceptance by the Government, the Contractor shall replace the aforementioned key switches by installing Government-furnished Phase I emergency recall operation and Phase II emergency in-car operation key switches to be tested by the Government during the final inspection and acceptance testing of the elevators.

Rate of rise/fixed temperature (57°C) heat detectors in the elevator machine room shall be arranged to automatically disconnect the main-line power supply. These detectors shall be placed near each sprinkler, and the sprinkler rating shall exceed the heat detector rating. The detectors shall be independent of the sprinkler system. The heat detectors shall cause a shunt-trip circuit breaker to disconnect the main-line power to the affected elevators prior to the application of water.

In an attempt to standardize on the controller for elevators, the NIH has made the decision to utilize the controller manufactured by Computer Elevator Corporation. This is called the Spectra 5000. This controller is compatible with the elevators of any of the major elevator suppliers.

The NIH requires that permanent lighting be placed within the hoistway of all elevators. Single-lamp 1.2 m fluorescent strip fixtures shall be mounted vertically every third floor. The circuit for these lights shall be controlled, as a minimum, by a three-way switch accessible from the top and bottom stops of the elevator. The switch may be a regular switch within the hoistway, accessible from the top of the car, or a keyed switch in the lobby area of the top and bottom stops.

The solid-state elevator control devices are not easily programmed or manipulated except through specialized test and calibration equipment that is at least as complex as the elevator controls themselves. Since the NIH performs most of its own maintenance and repair work on the elevators, the design for new or replacement elevators shall include the requirement that the elevator contractor supply to the Government any specialized test or calibration equipment that is required to perform the test and repair work on the solid state control equipment. Elevators which use proprietary test equipment that cannot be furnished to the Government for its own testing program will not be permitted.

Silicone-controlled rectifiers (SCRs) shall be used in lieu of motor/generator sets for elevator power conversion. SCR-based equipment that is compatible with any of the major elevator manufacturers is available from General Electric and from Louis-Allis (Division of Magnetek, Inc.).

E.4.21 Reliability

The engineer shall evaluate the degree of reliability required for a given project. Design issues such as separately routed primary feeders, two versus multiple network transformers, transformer placement, and switchgear location all bear on the reliability issue. Emergency power choices will be discussed in that section. The value of the work being performed in the given building and the impact on research due to an outage must be considered.

E.4.22 Testing

Acceptance testing of primary cable, primary switches on network transformers, network transformers, network protectors, secondary switchgear motor control centers, generators, and automatic transfer switches shall be performed in accordance with the NETA. The minimum tests required for the given equipment are shown in Table No. 1:

Table No. 1
Tests Required for Electrical Equipment

Equipment	Test
15 kV Cable	Insulation Resistance
15 kV Oil Switch	Visual Contact Resistance Insulating Liquid

Network Transformer	Visual AC high-potential test on primary windings and switch Insulation Resistance (2,500 V meggar) on primary and secondary windings Turns Ratio on all tap positions Insulating Liquid Oxygen percentage Insulating Liquid (six individual tests) including dielectric breakdown voltage Insulating Liquid Dissolved Gas Analysis
Network Protector	Visual and Mechanical Insulation Resistance Current Transformer Ratio Contact Resistance Minimum Pickup Voltage
Secondary Switchgear	Visual and Mechanical Insulation Resistance High Potential Instrument Transformers
Power Circuit Breaker	Visual and Mechanical Insulation Resistance Pickup and Time Delay Values Operation
Motor Control Center	Visual and Mechanical Insulation Resistance Overload Bus and Starters
Grounding Electrode	Fall of Potential
Ground Fault	Visual and Mechanical Neutral to Ground Resistance Pickup and Time Delay
Generator	Visual and Mechanical Insulation Resistance Protective Relay Phase Rotation Load Test
Automatic Transfer Switches	Visual and Mechanical Contact Resistance Insulation Resistance Relay Settings Timer Settings Operation

E.4.23 Wire Color Coding

Wire insulation shall be color coded. Branch-circuit conductors shall have colored insulation. Larger conductors shall be taped with the appropriate color tape for a minimum 150 mm starting from the termination. Each conductor of multi-conductor cable shall be color coded the same as single conductors. Color coding shall be as in Table No. 2 for power conductors in the given voltage systems:

Table No. 2
Color Coding for Wire Insulation

	208/120 V	480/277 V
Phase A	Black	Brown
Phase B	Red	Orange
Phase C	Blue	Yellow
Neutral	White	Gray
Ground	Green	Green
Isolated Ground	Green with Yellow Tracer	---

Color coding for control cables may be of a uniform color provided permanent**,** numbered tape markers are placed on both ends and splice points of each conductor.

Direct burial of power and signal cables shall not be allowed. Where an existing direct buried street lighting circuit is being extended one or two poles, the circuit may be direct buried. Where the cable is direct buried, it shall be protected the full length by 25 mm x 150 mm nominal pressure-treated lumber 150 mm above the cable. The cable shall be buried 750 mm below grade. Plastic cable-marking tape 150 mm wide shall also be installed 300 mm below grade. The plastic marking tape shall be red or yellow and read CAUTION: BURIED ELECTRIC LINE. Where new circuits, street lighting or otherwise, are installed underground they shall be placed in PVC Schedule 40, rigid galvanized steel (RGS), or PVC coated RGS conduit.

E.4.24 Conduit

Conduit shall be metallic to provide a redundant ground path. PVC or aluminum conduit is not acceptable except as noted below. PVC conduit may be used in underground applications and shall be used in concrete ductbanks.

All conduits shall be clearly shown on the contract drawings. Homerun arrows with panel designation and circuit numbers are acceptable. All switchlegs and circuit continuations shall be indicated on the contract drawings. Conduits shall be clearly indicated where they are to be installed exposed and where they are to be installed concealed.

The couplings used on electrical metallic tubing (EMT) shall be raintight compression type. Set screw couplings shall not be allowed.

The minimum conduit size shall be 20 mm. Surface mounted conduit in wash down areas shall be IMC or RGS with threaded couplings. Flexible metal conduit (Greenfield) shall be used for lighting fixture connections (whips) and for connections to equipment subject to vibration, noise transmission, or movement. Lighting fixture connections shall be made with minimum 1.2 m and maximum 1.8 m lengths of flexible metal conduit in accordance with NEC 410-67. Liquid-tight, flexible metal conduit shall be used for motor connections and undercabinet lighting.

E.4.25 Surface Metal Raceway

Surface metal raceway shall be metallic; plastic is not acceptable. The nominal dimensions of the raceway shall be:

- Single channel 70 mm x 38 mm
- Two channel 120 mm x 44 mm
- Two channel 120 mm x 90 mm

Emergency circuits shall be wired in separate channels from normal circuits. Power and communications shall be in separate channels.

E.4.26 Busway

Busway shall have all copper bus. Aluminum busway shall not be acceptable. Ventilated busway shall be installed in dry locations not subject to moisture. Nonventilated busway may be installed in wet or dry locations. The contractor shall be responsible for field measuring for the busway prior to ordering.

E.4.27 Cable Tray

Galvanized steel is the preferred material to be used in ladder cable-tray construction for power cables. Ladder or center-spine cable-tray construction is acceptable for communications cable. However, other materials, such as PVC-coated steel and aluminum, will be considered. Cable trays shall consist of factory-manufactured units that bolt together in the field. The minimum cable-tray size for communications cable shall be 300 mm x 100 mm nominal. Fabrication in the field, other than the shortening of a single straight section per each straight run to meet field conditions, will not be permitted. Corners, intersections, and tee units shall be standard manufactured units for this purpose; modification of straight sections to meet these needs will not be permitted. Where vertical space permits, and as approved by the Project Officer, tees and intersections can be in the form of two separate, straight tray sections at differing elevations; minimum spacing between these sections in the vertical direction shall be 150 mm. Ventilated tray bottoms, in lieu of ladder rungs, will not be acceptable.

Cable trays are to be routed near the side of the utility or pedestrian corridor wherever possible. Cable-tray locations shall be coordinated with adjacent utilities so that the tray will be accessible for adding or removing cables in the future. Routing shall also be adjusted so as not to obstruct access to other utility items that would routinely require access for maintenance or adjustment.

The cable trays shall be supported directly from the building structure above wherever possible. Bridging of other utilities with a trapeze arrangement is acceptable. The spacing of the support points shall be as recommended by the cable tray manufacturer. Supporting cable tray from suspended ceiling construction shall not be permitted.

E.4.28 Panelboards

Circuit breakers shall be bolt-on type. Plug-in-type breakers are not acceptable. The breaker shall have a published ampere interrupting rating at 125/250 V DC. This latter requirement is sometimes referred to as requiring an E-Frame breaker. (A DC rating for the one-pole and two-pole breaker shall be assumed by the NIH to extend to the three-pole device as well, for purposes of this requirement.) The specified minimum DC rating is 5,000 A at 125/250 V DC. Note that some manufacturers do not publish this data, as it is an expensive procedure to have UL do the necessary tests to obtain the DC rating. Breakers without the DC rating or listing are not acceptable.

Every panelboard shall have a main breaker in the same enclosure, closet, or room. The main breaker can be likened to a local disconnect and must be readily accessible shall the panelboard need to be deenergized in an emergency situation.

Single-pole breakers shall not be ganged to form multipole breakers.

Series rated equipment is not acceptable.

The panelboard directories shall be typed and shall reference the actual room numbers for the circuits. This shall be specified as part of the Contractor's responsibility regardless of room numbers used on the drawings. The directory shall list the panelboard name and the name of panel fed from.

New panelboards shall contain 25% spare circuit breakers. The spare breakers shall be left in the OFF position, and the panelboard directory card shall list the word SPARE for these breakers.

New panelboards shall contain space for future circuits that amount to at least 25% of those required in the initial design.

Panelboards shall be located in electrical rooms or closets with code-required clearances and 76 mm minimum separation.

Bathrooms, labs, or other rooms requiring floor drains or plumbing in the floor shall not be located above electrical rooms or closets. No pipes, ducts, or equipment foreign to the electrical equipment shall be installed in, enter, or pass through electrical rooms or closets in accordance with NEC requirements.

Branch circuits shall not be served from panelboards located in an adjacent building, area, wing, or located on a different floor.

Panelboards shall be labeled with name and feeder source panel or riser source location. The nameplate shall be a phenolic laminate with engraved black letters on a white surround. Emergency panels shall be white letters on red surround. The panel name shall have 13 mm high letters. The words FED FROM PANEL XX OR SWGR XX shall be 7 mm high on a line below the panel name.

Panelboards shall have a 100% neutral bus, a ground bus, and all buses shall be copper. Panels serving high harmonic load content (50% nonlinear load) shall have a 200% neutral bus. All panelboard breaker busing (extension fingers) including spaces shall be rated for 100 A minimum.

Distribution panels shall be defined as those panels serving branch circuit panelboards and other three-phase loads. Distribution panels shall be labeled DP-1, 2, 3, etc. Table No. 3 shall be used in sizing distribution panels for future space allocation.

Table No. 3
Distribution Panel Sizing

Maximum Active Poles	Minimum Spare Poles	Total Poles
12	6	18
24	6	30
36	6	42
42	24	66
66	*	66

*As required

Branch circuit panelboards shall have 42 poles regardless of bus ampacity. Branch circuit panelboards shall be three-phase, four-wire, with ground bus and all copper busing.

Panelboards shall be provided with a hinged trim feature with a full-height piano hinge. The trim shall hinge open with the removal of a few screws. The panel door giving access to the circuit breakers only shall have a flush tumbler lock. All panelboard doors shall be keyed alike.

E.4.29 Electrical Closets

Electrical closets generally contain branch circuit panelboards. The closets require adequate space for code-required clearances, lighting, ventilation, and two duplex receptacles. In new work and complete renovations, electrical closets shall be minimum 1.5 m x 2.4 m for closets without transformers and minimum 1.8 m x 3 m for closets with transformers. Closets with transformers shall have ventilation (and/or cooling) sufficient for 2% of the total transformer kVA expressed in watts of heat load. Electrical closets shall be located such that the farthest 120 V device served is within a 23 m radius of the closet. A square superimposed in a 23 m radius circle has an area of approximately 900 m^2. Therefore electrical closets shall generally be placed one for every 900 m^2 of area served by 208/120 V branch circuit panelboards. Loads served with 277 V shall be no more than a 30 m radius from the closet. Converting to area, lighting panels shall be placed approximately one every 1,800 m^2. Obviously building configuration will change the area/closet, but the 23 m rule shall be maintained to avoid having to increase branch circuit wires size for voltage-drop reasons.

If the above-closet space is not available in small renovation work, shallow closets with full doors on the long wall are acceptable in corridors. Panelboards in laboratories and vivariums are generally located in service corridors and do not require closets.

Electrical closets within multistory buildings shall be stacked. The closets shall not be located adjacent to mechanical shafts so as to avoid interference problems with ducts and conduits above the ceiling directly outside the closet. Mechanical ducts, etc. shall not run through electrical closets as stated above per the NEC.

Lighting in electrical closets shall be one two-lamp fluorescent strip for the small closet and two fixtures for the large closets. The lighting shall be connected to emergency power when available.

One duplex receptacle shall be wired to emergency power and one to normal power in each electrical closet.

During renovation work, the designer shall not obtain new circuits from panelboards in remote areas or other floors of the building. Holes in the floors of electrical closets shall be sealed watertight. Wherever possible, the floor shall be provided with sleeves extending at least 70 mm above the floor.

E.4.30 Receptacles

The standard color for receptacles is ivory. Receptacles serving computers shall be grey, except that isolated ground receptacles shall be orange color. Where isolated ground circuits are required, an isolated ground conductor (see section E.4.23, Wire Color Coding) shall be installed with the branch circuit. See section E.8, Power Quality, for panelboard isolated ground bus requirements. Receptacles serving printers shall be blue. Receptacles connected to emergency power shall be red. Receptacles shall be installed such that the ground prong is mounted in the up position unless mounted 1.67 m AFF or higher. This is a safety requirement in the event the plug is partially pulled out and something metallic falls on the prongs of the plug.

Offices shall have minimum one general (ivory) receptacle per wall.

General-purpose receptacles shall have a design load of 180 VA each in accordance with the NEC. For circuiting purposes a maximum of six receptacles shall be connected to a circuit. This allows a future expansion of two receptacles per circuit.

Personal computers (PCs) shall be limited to three per 20 A circuit. Printers shall be limited to two per 20 A circuit. Computer and printer receptacles shall not be connected to the same circuit, nor to the general (ivory) receptacle circuits.

A 20 A duplex receptacle shall be mounted within 7.6 m of and on the same level as any electrically operated equipment on rooftops, in attics, and in crawl spaces. The receptacle must be on a separate circuit than that serving the equipment. Receptacles mounted outdoors shall be GFI type.

Tamperproof safety-type receptacles are required in pediatric, psychiatric, and child care areas. Temperproof receptacles shall operate with a 2 or 3 prong plug.

Special duplex or single receptacles to serve specific equipment or loads shall be indicated by NEMA configuration.

E.4.31 Demolition

Where the work requires that wiring be removed from conduit that is not embedded in concrete, and if that conduit is not scheduled for reuse on the same project, then the conduit is to be removed.

Exception:

The lighting switchleg conduit is connected to the first outlet box if wall containing switch is to remain.

Vertical conduit is connected to the first outlet box at panelboard if the panelboard is of the recessed type.

Where the work requires that the wiring be removed from an embedded-in-concrete conduit, and if that conduit is not scheduled to be reused, the conduit is to be abandoned in place. Conduit that enters the slab from below is to be cut, after the wires are removed, as close to the slab as practical but with not more than 19 mm protruding. Conduit that enters the slab from above shall have the floor material removed so that the conduit can be cut with a cold chisel at least 6 mm below the slab elevation, and then the conduit and enlarged opening shall be plugged with nonshrinking grout and the slab surface finished flat and true.

E.4.32 Disconnects

Disconnect switches shall have a minimum clear mounting height of 460 mm above grade outdoors and 1 m above finished floor in interior spaces.

E.4.33 Electric Heat

Electric heating will not be used to heat NIH buildings. Very limited use of electric heating will be permitted provided the engineering staff of the NIH Division of Engineering Services concurs that this is the only feasible solution to an atypical situation.

E.4.34 Nameplates

All electrical equipment shall have nameplates identifying the name of the piece of equipment or the name of the equipment served (disconnects, starters, etc.). Nameplates shall be laminated phenolic legend plates with white letters on black surround for normal power and white on red surround for emergency power. Nameplates shall have minimum 7 mm high letters for small equipment and disconnects, 13 mm high for medium-sized wall-mounted equipment such as panelboards and individual Size 2 starters and above, and 50 mm high for freestanding equipment such as large panelboards, switchgear, and liquid-filled transformers. The nameplates shall be attached with stainless steel screws. Where the equipment is remote from its electrical source, under the equipment name in smaller letters the words FED FROM followed by the source panel or riser name shall be included.

E.5 Emergency Power

Historically the NIH has experienced outages of 1 hour or less once a year and outages of 4 hours or less once in 10 years. Generators are exercised weekly with a load bank, and automatic transfer switches (ATSs) are exercised monthly. The exercising of an ATS causes two momentary outages to the load, one going to diesel power and one returning to normal.

Generators shall be rated for 100% nonvarying continuous load, not standby or prime rating.

E.5.1 Outdoor Generator

The preferred generator location is outdoors in a sound-attenuated enclosure with adequate working space about the generator. Consideration shall be given to diesel exhaust, feeder length, aesthetics, space requirements, ease of removal, air intakes, etc. when locating the generator on the site. The sound attenuated enclosure shall provide 70 to 79 dB maximum noise level 6 m from the enclosure at rated output regardless of the generator size.

Power and monitoring wiring shall be provided for the remote tank-level gauge.

The generator location shall have self contained battery powered lighting on both sides of the generator(s) connected to emergency power.

The generator exhaust silencer, or muffler, shall be rated for minimum residential use or quieter to achieve the required sound rating. The location and direction of the engine exhaust shall not adversely affect the air intake for the building. The preferred direction of the exhaust is up, from a sound rating standpoint. A hinged rain cap shall be provided on vertical discharge exhaust pipes.

Generators 400 kW and larger shall be provided with a load bank. Load banks for smaller generators are optional and recommended on lightly loaded generators. Generators shall be exercised at the demand load or 95% of generator capacity, whichever is larger. Load banks mounted on the radiator exterior are recommended.

The load bank shall be wired through a shunt-trip circuit breaker. The load-dump control circuit in the load bank shall be wired to the transfer switch(es).

If the building calls for emergency power while the generator is being exercised by the load bank, the load bank circuit breaker shall immediately open, dropping the load bank from the generator bus.

An on-site minimum fuel storage capacity of 48 hours run time at 100% load shall be provided. Fuel-tank leak detection shall be provided.

The fuel supply line from the storage tank to the day tank shall have a hand-operated pump of the crank type, as well as an electric pump in nongravity locations. The overflow line from the engine shall be returned to the storage tank, not the day tank. In gravity situations where the main fuel tank is higher than the generator, a "reverse day tank" (return storage tank) shall pump excess fuel back to the main tank.

Fuel lines shall not be routed on the surface of the floor or anywhere subject to wear or physical damage.

The generator day tank and battery charger shall be connected to emergency power. The jacket water heaters shall be connected to normal power. Where an oil circulation pump is provided to circulate oil through the engine top end, it shall be connected to normal power.

The diesel distribution system is defined as the system delivering power from the generator to the emergency terminals of the automatic transfer switch (ATS). Diesel power is normally dead until the generator is on line. Normal power is delivered to the normal terminals of the ATS. Emergency power starts at the load terminals of any ATS. Diesel power is distinguished from normal power which is live normally, and emergency power which is live all the time except during the brief engine start-up period (5-10 sec.).

Where two or more ATSs will be installed, an emergency diesel distribution panel EDDP shall provide for future addition of ATSs with minimal interruption to the diesel power system.

The number of switched poles (three or four) in a transfer switch shall match the existing where replacement or upgrade is occurring. The lifting of the generator neutral to ground bond shall comply with NEC requirements for three-pole, solid neutral transfer switches. New construction or complete renovation projects shall utilize four-pole switches on three-phase, four-wire systems. The generator neutral shall be grounded when using four-pole switches in accordance with NEC requirements.

ATSs shall have override switches to cause them to transfer to the other source only if it is a good source. A "good source" is defined as one with line voltage ± 10% available and frequency of 60 Hz ± 1/2%. ATSs shall have external manual operators (EMOs) to mechanically operate the ATS under load without opening the enclosure door. Pushbuttons shall not be used as EMOs. The EMO shall transfer the switch to any position regardless of the condition of the source. ATSs without center off time delay shall have an in-phase band monitor. ATSs shall have center off time delay when serving motors. ATSs shall be located indoors. If a waiver is granted for an outdoor location, the ATS shall have door-in-door NEMA Type 4X construction with strip heaters inside the enclosure. The strip heaters shall be connected to emergency power.

The transfer switch shall be UL listed in accordance with UL 1008.

The ATS shall be provided with a complete metering package supplied on the load side of the device. These meters shall monitor the load whether the source is normal or diesel power. Metering shall consist, as a minimum, of voltmeter (phase to phase and phase to neutral), ammeter (per phase and average three-phase), frequency meter, and kW demand meter, plus associated switching devices.

The operating mechanism of the transfer switch shall be electrically operated, mechanically held. ATSs shall not be manufactured utilizing two circuit breakers with the trip handles physically connected. The cable connection points for the two inputs and load shall have a phase-to-phase spacing of at least 70 mm.

Bypass transfer switches shall be used where the load cannot be taken out of service or the scheduling of an outage is extremely difficult. Transfer switches shall be maintained once a year. With a bypass switch the transfer switch can be taken out of service with only a momentary outage to the load. The user shall be made aware of the added cost of a bypass transfer switch so as to make an educated decision. The size of a transfer switch will also increase with the addition of the bypass function. The bypass switch shall be capable of manual operation to either source, under load, regardless of the condition of the source or transfer switch position. The manual operator shall be readily and permanently accessible without opening the enclosure door.

E.5.2 Indoor Generator

If site constraints are such that the generator must be located indoors, the following design requirements apply.

Provide sound attenuated room to suit the generator being installed and the surrounding occupancies.

The design for the volume of air delivered to the interior space where a generator is located must include the combustion air that exits out the exhaust stack and the cooling air that flows through the radiator. Note that the air that flows through the engine radiator is heated, and this expanded air, if used for combustion, will reduce the engine efficiency.

The cost of conditioning the air to be used for the needs of the generator dictates that outside air be used wherever possible. This requirement has no impact upon combustion air, but cooling with outside air will require that the coolant in the generator contain a chemical antifreeze ingredient.

The outside air intake for combustion air shall be coordinated so that there is little chance that the building exhaust (which might contain smoke in a fire situation) will be drawn in for combustion air.

The ventilation air intake shall be coordinated such that it does not draw in engine exhaust.

Where the engine exhaust from the indoor generator exits the building through a wall, or penetrates interior floor slabs or the roof, an insulating thimble must be used to protect adjacent materials from the excessive heat that would be created by full-load operation.

The design that places a generator within a new building must also provide a suitable exit route for removal of this equipment shall replacement be necessary in the future. This route shall be clearly delineated on the drawings and in the field, e.g., painted lines on the floor or walls, etc.

The air for either cooling or combustion purposes shall be primary filtered as it enters the building from outside. The engine filter shall be considered a second and final filter for indoor units.

The following loads are required to be connected to emergency power. These loads are in addition to any code required emergency loads:

- Supply circuit (as required) for each uninterruptible power supply (UPS) provided by the user
- Automatic temperature control **s**ystem components
- Building heating water system

The following loads may be connected to emergency power:

- CCTV cameras and equipment
- Security system

A duplex receptacle on the emergency system shall be placed in the corridor within 6 m of each stairwell entrance. This receptacle is primarily for the use of the NIH Fire Department in emergency situations and shall be so marked with appropriate signage so that the receptacle will not be blocked or hidden by equipment.

One single 20 A three-wire twistlock receptacle (NEMA Type L5-20R) shall be installed at least as high as and 0.60 m offset from the hose connection outlet to each standpipe. The receptacle shall be located in the corridor adjacent to the stairwell. Each outlet box shall be painted fire-alarm red in color and be marked <u>Only for Fire Department Use</u>.

Any building requiring standpipes shall have installed one 30 A, 120 V circuit for each standpipe riser to the above listed twistlock receptacle. The receptacle shall be supplied from the emergency panel. The wiring method for exposed work shall be RGS conduit. Boxes shall be metal, weatherproof type, with gasketed flap-door covers and threaded hubs. The wiring method for concealed work shall be conduit with appropriate galvanized boxes having gasketed flap-door covers suitable for Fire Department use. The weatherproof cover shall be suitable for receiving the NEMA Type L5-20R twistlock receptacle without damage.

E.5.3 Fire Pumps

Where a generator is required or desired, and where a fire pump is required, it shall be connected to the generator.

The fire pump emergency diesel feeder shall be connected at the generator where one generator provides emergency power to the building. The fire pump feeder shall be connected to a separate main circuit breaker from the building emergency diesel feeder. The fire pump circuit breaker shall be sized to start the fire pump with all other fire pump room loads on the feeder energized. The generator shall be sized to start the fire pump with all other loads connected to the generator energized. Load dumping of nonessential loads is allowed prior to starting the fire pump.

If the building emergency power system consists of multiple generators paralleled to a bus, then the fire pump diesel feeder shall not be connected at the generator. If the paralleling switchgear distribution circuit breakers are housed in switchgear construction with individual breaker compartments, then the fire pump feeder shall be connected in the paralleling switchgear. The fire pump feeder breaker shall be in the bottom compartment of one of the switchgear sections. The distribution switchgear circuit breakers shall be air drawout power circuit breakers similar to the normal-service secondary switchgear breakers.

If the paralleling equipment is not switchgear construction on the distribution end, then the fire pump overcurrent device shall not be in the paralleling switchgear. The fire pump feeder shall be tapped ahead of any distribution circuit breakers and feed a separately mounted overcurrent device. The overcurrent device shall be mounted on a wall in the room with the paralleling equipment. The enclosure shall be painted red and clearly labeled FIRE PUMP EMERGENCY DISCONNECT in 25 mm high white letters.

The fire pump feeder from the emergency source to the fire pump controller shall be installed in accordance with NFPA Standard 20.

The ATS for the fire pump shall be in the fire pump room. The transfer switch shall be supplied with the fire pump controller. The routing of the normal and diesel feeders to the fire pump room shall be separate.

The jockey pump, lighting, receptacles, etc. in the fire pump room shall be connected to emergency power and not to the fire pump feeder.

E.5.4 Bypass Breaker

A bypass circuit breaker may be provided so that in an extended power outage the surplus generating capacity of the on-site generators can be shunted to non-emergency loads. Where a bypass breaker has been provided for this purpose, this breaker must be key interlocked to prevent any possibility of normal power, when it is restored, being connected in parallel with the local generator.

E.5.5 Generator Receptacles

The NIH Institutes, Centers, and Divisions shall review their research need for reliability of electrical power. The use of an on-site diesel generator is a requirement for most research activities, including any programs which require animal husbandry. Where a generator is deemed necessary, generator receptacles shall be provided as outlined below.

For small on-site diesel generators, 250 kW or less, the usual practice is to provide generator receptacles for the connection of a mobile load bank for the monthly load test of the generators. These receptacles can also be used to connect a mobile generator, shall the on-site generator be out of service.

For on-site diesel generators larger than 250 kW, a dedicated load bank shall be provided with the generator for load testing. Generator receptacles shall be provided.

Generator receptacles shall be located 1 m above finished grade at or near an accessible roadway, parking lot, or loading dock. A receptacle bank shall include the following devices:

200 A, 480/277 V, four-pole, five-wire Russell-Stoll junction box, angle adapter, and pin and sleeve receptacle. The quantity of 200 A receptacles shall match the generator output.

One Woodhead 15 A, 125 V, two-pole, three-wire NEMA Type 5-15R with a flip-lid cover for 120-V AC load bank control or battery charger.

One Woodhead 15 A, 125 V, two-pole, two-wire-locking NEMA Type L1-15R with a flip-lid cover for remote start circuit.

One Woodhead 20 A, 250 V, two-pole, three-wire-grounding NEMA Type 6-20R with a flip-lid cover for 208 V AC heater circuit.

The last three receptacles above shall be installed in a Woodhead box, directly adjacent to the boxes containing the Russell-Stoll receptacles, and the wiring may be combined with the larger power conductors.

E.6 Motor Control

Motors shall be operated on the system voltage noted in Table No. 4:

Table No. 4
Motor Control

Motor Rating (V)	System Voltage (V)
115	120
200/208	208
460	480

Motors with ratings other than those listed shall not be connected.

Thermal manual motor starters (TMMSs) shall be of the nonautomatic resetting type and shall be lockable in the off position.

Three-phase motor starters shall be sized by the NEMA rating. Motors 37,300 W and larger shall have reduced-voltage starters.

Motor starters shall be combination type with a fused disconnect or a motor circuit protector.

Three-phase motor starters shall have integral single-phase protection against loss of any phase voltage. Solid-state overload relays provide this function inherently.

Pilot devices to be included in three-phase motor starters are:

- Red running pilot light
- Green power available pilot light
- Hand-off-automatic (HOA) switch
- Control power transformer (CPT) with two primary and one secondary fuse; secondary voltage shall be 120 V.
- 2 N.O. and 2 N.C. auxiliary contacts with the capability of adding more
- Mechanical override to open the starter enclosure while energized

Motor control centers (MCCs) shall be provided where four or more motors are located in an area. MCCs shall have copper bus and plug-in starters with no hard wiring directly to the starter. All control wiring (in or out) shall be extended to terminal strips in a central location in the MCC in accordance with NEMA Standard ICS 2-322, Type C wiring.

Motor starters shall conform to IEC 947-4-1 Type 2 component protection in the event of a short-circuit.

Ladder diagrams and sequences of operations shall be provided for all control functions. This applies to heating, ventilating, and air conditioning (HVAC), automatic temperature controls (ATC) (pneumatic or electric), plumbing, fire protection, security, programmable lighting control, etc.

Motor starter enclosures shall be NEMA Type 1 indoors, NEMA Type 4 outdoors, and NEMA 4X in corrosive environments.

High-efficiency motors shall have the overcurrent protection sized in accordance with the manufacturer's recommendations.

Variable-frequency (speed) drives (VFDs) shall be as specified in section D, Mechanical, to yield better coordination between the motor, the drive, and the driven piece of equipment.

Power factor correction capacitors shall be applied to motors 7.5 kW and larger. The capacitors shall be wired directly to the motor terminals.

E.7 Lighting

Lighting requirements shall follow the IESNA *Handbook* except as noted herein. Light levels for specific areas are listed in the respective volumes of the Design Policy and Guidelines. General lighting requirements not listed in other volumes or in the Energy Conservation section of this volume will be presented here.

The most common lighting fixtures on the NIH campus are the recessed 600 x 600 mm and 600 mm x 1200 mm fluorescent troffers. All 600 mm x 1,200 mm fluorescent troffers shall meet the criteria in Table No. 5:

Table No. 5
Criteria for Fluorescent Troffers

Description	Criteria		
	600 mm x 1,200 mm	600 mm x 600 mm	300 mm x 1,200 mm
Depth	120 mm	120 mm	140 mm
Body Metal Thickness	22 gauge	22 gauge	22 gauge
Endplate Metal Thickness	20 gauge	20 gauge	20 gauge
Door Material	Aluminum with mitered corners	Aluminum with mitered corners	Aluminum with mitered corners
Door Latches	Cam type	Cam type	Cam type
Paint Reflectance	90%, pre- or postpainted	90%, pre- or postpainted	90%, pre- or postpainted
Coefficient of Utilization (CU)	.89 minimum at room cavity ratio (RCR) of 1.0 and ceiling/wall/ floor reflectances of 80%/50%/20%	.83 minimum at RCR of 1.0 and ceiling/wall/ floor reflectances of 80%/50%/20%	.79 minimum at RCR of 1.0 and ceiling/wall/ floor reflectances of 80%/50%/20%
Lens	3.2 mm thick pattern 12 100% acrylic with flat prism surfaces	3.2 mm thick pattern 12 100% acrylic with flat prism surfaces	3.2 mm thick pattern 12 100% acrylic with flat prism surfaces
Lens Brightness at 75^{o} and 85^{o}C with 4-3,200 lumen lamps	2,056 cd/m^2 maximum	2,056 cd/m^2 maximum	2,056 cd/m^2 maximum
Average Lens Weight	2,390 g/m^2 (not 2069)	2,390 g/m^2 (not 2,069)	2,390 g/m^2 (not 2,069)
Lamps	3 T-8, 32 W, 1,200 mm	2 T-8, 32 W U-Lamp	2 T-8, 32 W, 1,200 mm

Ballast(s)	Electronic Rapid Start	Electronic Rapid Start	Electronic Rapid Start
Power Factor	.99	.99	.99
Harmonic Distortion	<13% THD	<13% THD	<13% THD
Crest Factor	<1.5	<1.5	<1.5
Lamp Connection	Parallel	Parallel	Parallel
Efficacy	>80 LPW	>80 LPW	>80 LPW
Ballast Factor	.85 to .95	.85 to .95	.85 to .95

E.7.1 Lamps

Fluorescent 1,200 mm lamps shall be 32 W T8 (25 mm diameter.) 3,500 K color temperature with a CRI of 77 and rated average life of 20,000 hours. Compact fluorescent lamps shall be made with 13 mm diameter tubes, 2,700 K color temperature with a CRI of 82 and rated average life of 10,000 hours. The compact fluorescent lamp wattage shall very according to the application.

Compact fluorescent lamps are recommended in all but the most critical color rendering applications. In those few specific applications, incandescent lamps may be utilized. The PAR halogen infrared (HIR) lamps are recommended for lumen output of 1,150, lamp life of 3,000 hours.

Standard incandescent PAR and R lamps shall not be specified since they were discontinued October 1995. Halogen versions of the PAR and R lamps shall be submitted for the standard incandescent.

Finished rooms or spaces with 3 m minimum ceilings may utilize metal halide (MH) lamps. Open fixtures shall be utilized only with metal halide lamps rated for same. Metal halide lamps shall have a color temperature of 3,200 K, rated life of 5,000 to 15,000 hours depending on the wattage, and a minimum CRI of 65.

E.7.2 Fluorescent Lamp Ballast

Ballast shall be solid-state electronic type consisting of rectifier, high-frequency inverter, and power control and regulation circuitry. Ballast shall be UL listed, Class P thermal rating, and Class A sound rating, per UL 935-84 and certified as follows by lighting ElectronicTesting Laboratory (ETL) or UL and labeled by Certified Ballast Manufacturers Association (CBM). Ballast shall be rated for the actual number of lamps served, and the voltage shall match the connecting circuit voltage. Ballast shall have an operating frequency of 20 kHz or greater. Ballast shall contain no polycholorinated biphenyls PCBs. Light regulation shall be plus or minus 10% with nominal plus or minus 10% voltage variation. Lamps shall be operated in rapid-start mode. Ballast shall be designed to withstand transients described in IEEE Standard 587, Category A. Ballast temperature rise shall not exceed 25^{o}C over 40^{o}C ambient. Ballast shall meet Federal Communications Commission (FCC) regulations, Part 18. Ballast shall have a minimum 5-year warranty.

The following types of light sources shall be used where noted:

Area	Light Source
Site Lighting - Roadways and sidewalks	High-Pressure Sodium (HPS)
Architectural Lighting	HPS or Metal Halide (MH)
Landscape Lighting	MH or HPS
Loading Docks	HPS
Parking Garages	HPS or MH

Lighting designers shall be concerned about light pollution, or the intrusion of NIH light on bordering neighbors. The use of "house side shields" on fixtures, or light fixtures with good "cut-off" optics for glare control shall be utilized near the NIH property line. The placement of lighting poles near the property line shall be avoided and will be scrutinized by the NIH and the neighborhood associations.

Site lighting poles shall have a 75 mm x 25 mm aluminum tag riveted to the pole. The tag shall clearly identify the building, panel, and circuit number where the service is derived.

Street lighting shall utilize a "cobrahead" fixture mounted 8 m above the pavement with a 250 W HPS lamp. The mounting arm shall be 1.8 m long. Where poles are placed immediately at the edge of a parking lot or other areas where automobile bumpers may come in contact, the pole shall be mounted on a 1 m high concrete base for protection. The pole shall be shortened accordingly to maintain the 8 m mounting height.

The street-lighting units are generally placed about 30 m to 36 m apart along the majority of the two-lane roads at the NIH. This gives a minimum average maintained lighting level of about 50 lx on the roadway. Similarly, the walkway-lighting units are spaced about 25 m to 30 m apart, which gives a minimum average maintained lighting level of 10 lx. Various specific locations have been targeted as high-crime or high-accident areas, and the spacings have been reduced or the lighting augmented to increase the above footcandle levels.

All street-lighting circuits are controlled at the point of origin by a photoelectric cell mounted on the side of the building where the circuit originates. A switch is provided to bypass the photocell so that the circuit can be energized during the day for trouble-shooting purposes. Site lighting circuits shall use minimum #6 AWG wire in minimum 38 mm PVC conduit. The maximum circuit breaker size protecting site lighting circuits shall be 30 A. The plastic conduit is placed at least 600 mm below grade, and a 150 mm wide plastic warning tape is placed above it at 150 mm below grade.

When a new street lighting pole is installed, it is required to have a 3 m long, 19 mm diameter, copper-clad ground rod placed in the foundation, and all metallic components shall be grounded to the rod, such as the metal standard, the ground wire pulled in with the power circuit, and an equipment ground wire to the luminaire.

Outdoor lighting circuits shall not have underground splices or tee splices. If splices are necessary, they shall only occur in accessible locations in light pole bases.

Walkway lighting fixtures are typically mounted on 3.5 m poles with 150 W HPS lamps. Walkway lighting shall match the fixtures in the area. Walkway lighting near buildings may vary to blend with the architecture, especially near a historic building.

Parking garages above grade with open construction shall have the perimeter fixtures controlled by a photocell. The perimeter fixtures shall be of the glare control type with a flat lens rather than the drop-lens type. Internal fixtures may have the drop lens to achieve good vertical footcandles.

A lighting fixture schedule shall list at least two manufacturers and model numbers, and preferably three. A note indicating "or approval equal" shall be included at the bottom.

Recessed fluorescent lighting fixtures shall be supported from the building structure on minimum two diagonal corners independent of the ceiling construction. Steel wire shall be minimum 3.5 mm.

The office average maintained light level using a maintenance factor of 75% shall be 500 to 800 lx. For values in other types of spaces see the Laboratory, Vivarium, and Clinical Center Guidelines.

Circuit connections to lighting fixtures shall be made with minimum 19 mm flexible metal conduit, maximum 1.8 m in length.

Lighting fixture pendants shall be minimum 13 mm diameter stems with swivel mounts.

Industrial fluorescent lighting fixtures shall have a wire guard or plastic sleeves over the lamps. Shelf-mounted, open-strip light fixtures shall also have plastic sleeves over the lamps.

Site-lighting circuit voltages of existing circuits may be obtained from the NIH Electric Shop in Building 13.

Animal loading docks and food service loading docks shall use HPS lighting. Loading docks shall be provided with 120V source(s) for bug "zapper" fixtures.

The electrical lighting plan drawings shall contain enough information so that the number of wires in each conduit run is easily discernible. The use of switch labels and corresponding labels at each fixture is not sufficient. The Contractor shall not have to lay out the room wiring diagram (i.e., perform the design function) in order to determine the number of conductors needed between fixtures or between fixtures and switch locations.

The use of computer aided design and drafting (CADD) methods to generate drawings has led to some designers trying to put the minimum amount of information on the drawings. In addition, the traditional method of showing wiring connections with a gently curving line is being replaced with straight lines and sharp angles. Reading these CADD drawings is more difficult, especially where lines are close together or overlapping. The designers shall remain responsible for the readability of their documents.

E.7.3 Exit Signs

Exit Signs shall be connected to emergency power. Where emergency power is not available in the building, battery exit signs shall be used. See the Energy Consevation section for more information on exit signs.

E.8 Power Quality

E.8.1 Grounding

A solid-grounding electrode system shall be provided to ground the service entrance equipment. Where a pad-mounted transformer is utilized, a ground ring of #4/0 AWG bare copper conductors shall be provided around the transformer pad. Ground rods shall be placed approximately 1 m outside each corner of the pad. Two #4/0 AWG conductors shall be brought up into the transformer enclosure for equipment grounding. The transformer neutral shall only be grounded inside the service entrance (SE) equipment in the building. A #4/0 AWG ground conductor shall extend from the outdoor ground ring underground to the main electric room ground bus.

A similar ground ring shall be installed surrounding the main electric room (or indoor transformer vault) with ground rods in each corner and maximum 6 m on center around the perimeter of the room. Ground conductors shall be connected to a wall-mounted ground bus at each end of the bus and at each ground rod between.

The ground bus shall be 51 mm x 6.4 mm copper and extend the length of the two long walls of the transformer vault, if provided, and the secondary switchgear room. The ground bus shall be mounted 300 mm above finished floor (AFF). Ground conductors leading to the ground ring shall be exothermically welded to the ground bus; all others shall be bolted. Equipment and grounding electrode conductors (all bolted conductors) shall be labeled. Labeling shall utilize embossed brass metal tags with nylon tie wraps.

Ground conductors brought through the floor or walls shall be in PVC conduit sleeves. Ground conductors shall not be located in traffic areas or where subject to damage. However, where ground leads through the floor are subject to damage due to layout changes, the PVC sleeve shall be cut off flush with the floor. A steel "C" channel shall be placed face down over the penetration to form a protective bridge. The "C" channel shall be bolted to the floor with the ground wire exiting one end.

Feeders and branch circuits shall contain equipment ground conductors sized in accordance with the NEC.

Panelboards serving isolated ground receptacles shall have an isolated ground bus in addition to the equipment ground bus. The isolated ground bus shall not be bonded to the panelboard enclosure or equipment ground bus. Isolated ground receptacles are typically required in laboratories and offices. The buses shall be clearly labeled. An isolated ground conductor shall be sized to match the phase conductor. The isolated ground conductor shall be isolated to the separately derived power source.

E.8.2 Harmonics

The power supplies found in any computerized equipment such as PCs, laser printers, file servers, electronic ballasts, VSDs, and uninterruptable power supplies (UPSs) impose third-order (180 Hz) and higher harmonic currents on the neutral conductor of three-phase, four-wire electrical systems. The triplen (multiples of three) harmonics add in the neutral conductor. The worst-case 100% total harmonic distortion would create a neutral current of 1.73 times the phase current.

Where a high concentration of computer loads relative to all other noncomputer loads is anticipated, precautionary measures shall be taken. The following shall be provided where a large percentage (60% or more) of the load is or will be computerized:

- Full-size individual neutrals in branch circuits
- Branch circuit panelboards with 200% neutrals
- Transformers with K rating of K-13 and 200% neutral from transformer to panel
- Adequate cooling in electrical rooms
- Separate dedicated circuits for printers and PCs.
- In extreme cases where two high harmonic loads are approximately equal, a phase-shifting transformer will shift the current of one load (feeder) relative to the other such that the harmonic currents cancel. This type of transformer is typically used to fix an existing problem and is difficult to apply during design unless specific information is known about the load.

E.8.3 Transients

The NIH has not experienced many problems with transients to date. Therefore, at this time no specific requirement for transient-voltage surge suppression (TVSS) is made. However, if the user has very sensitive electronic equipment without UPS protection, TVSS protection may be prudent. A layered protection plan is recommended. ANSI/IEEE Standard C62.41 Category C3 TVSS protection shall be provided at the SE and Category B3 TVSS protection, at the downstream branch circuit panel.

E.8.4 Lightning Protection

New buildings at the NIH shall be evaluated for lightning protection based on the guidance provided by the latest NFPA Standard 780, Lightning Protection Code.

Lightning protection where required or desired shall meet the most restrictive requirements of the following:

- NFPA 780
- LPI-175
- UL

Low buildings may be protected by the lightning protection installed on an adjacent higher building. The above-listed standards show the zone of protection.

New buildings that need lightning protection shall receive a Master C Label from UL after the new lightning protection system is evaluated by UL and found to be acceptable. The UL label confirms that the whole structure, including all roof levels and terraces, is protected against lightning strikes.

As existing buildings are altered or modified, especially when the outer envelope is changed, the lightning protection system shall be updated and the protection verified. The vehicle for this is a UL Letter of Finding, rather than a review of the entire building. If a whole building review is required, then a new Master C Label is issued, and this is called a Reconditioned Master Label.

When a lightning protection system is to be installed on a new building, a ground girdle shall be provided encircling the entire building. All metallic objects such as pipes and conduits crossing the ground girdle shall be bonded to the ground girdle.

All electrical service entrance, generator, telecom, and LAN grounding systems shall be grounded to the lightning protection system.

E.9 Fire Alarm

The contractor shall not perform changes to an existing active fire alarm system. This includes connecting new equipment or systems into the base loop. These operations must be performed by the NIH Division of Engineering Services, Shops Branch. If an existing system or a part thereof needs to be altered, then the procedure is to obtain approval prior to system outage via normal procedures, wherein the NIH Shops Branch will isolate the branch or system to be altered. Later, after changes have been effected, the contractor will test the new equipment or system in the presence of the Fire Prevention Section, EMB, Division of Safety, and the NIH Shops Branch personnel, who will put the equipment into service after all devices and circuits have been checked for deficiencies.

The same procedures apply to connecting a new building or system into the NIH Base Loop. The NIH Shops Branch will witness the final tests and will then connect the new system into the Base Loop.

New buildings shall have a stand-alone fire alarm system installed. The system shall be tied into the NIH Base Loop as described above.

Fire alarm notification appliances shall match existing equipment, in renovation projects.

There shall be an automatic dialer provided in all new buildings to work in conjunction with the fire alarm system. The dialer shall call up to a transmitter in Building 10 that will transmit a special signal to energize pocket pagers worn by the audibly handicapped when working within that new building. An administrative procedure shall also be established which will allow the audibly handicapped to trade their pocket pagers for a different one when there is a need for travel between buildings.

Large construction projects and animal holding/procedure areas shall have a fire alarm voice communication system. Upon alarm, the fire alarm speakers are to sound a "slow-whoop" signal, at 90 - 100 dB, for four cycles, followed by a voice evacuation message. Upon completion of the voice message, the slow-whoop shall resound and continue until the fire alarm control panel is reset or the "alarm silence" switch is activated.

All concealed fire alarm conduit and conduit in the stairwells, storage rooms, and utility rooms shall be painted red enamel. All exposed fire alarm conduit (outside of the stairwells) shall be painted to match the existing adjacent wall surface, and 100 mm wide red enamel bands shall be painted at 3 m intervals. This painting requirement also applies to the pull boxes, junction boxes, and mounting boxes and extensions.

The fire alarm wire for 120 V circuits shall be #12 AWG, solid copper, TFN insulation. The fire alarm wire for 24 V DC circuits shall be #16 AWG, solid copper, TFN insulation.

Color coding for fire alarm system devices shall be zone coded, with a code color change on the return loop if the end-of-line resistor is placed within the fire alarm panel.

All fire alarm wiring shall be installed in rigid metal conduit or EMT.

The fire alarm field devices (initiating, notification appliance, and interface equipment) shall be shown on the electrical power floor plans or special systems floor plans.

The fire alarm design shall include a complete fire alarm riser diagram. The riser diagram shall show all panels, field devices, conduit sizes, wire sizes, and quantities.

Heat detectors shall be combination fixed-temperature 57^{o}C and rate-of-rise units. High-temperature areas shall be equipped with appropriate high fixed temperature heat detectors.

Corridors 1.5 m wide or wider shall have smoke detectors.

Duct smoke detectors shall not be installed in air-handling units of less than 7,080 liters/s, in air-handling units which serve only one fire area, or in fully sprinklered buildings except in health care occupancies. Installed duct smoke detectors shall be photoelectric type connected to the building fire alarm system, and shall result in automatic air-handler shutdown. Duct detectors shall be resettable from the control panel.

E.10 Local Area Network (LAN)

The LAN system commonly refers to data transmission on the NIH campus. Most data, whether it is research or system monitoring, etc., travel on the LAN system. Any voice communication travels on a separate system discussed in the telecom section. The following are requirements for the LAN system.

Fiber optic and copper cable shall be installed under a separate contract by the NIH or the user. The raceway and other details as described below shall be designed into the construction documents. The raceway shall be installed in accordance with EIA/TIA standards. The Inter-Building Closet (IBC) shall be minimum 8 m^2 with one minimum dimension of 2 m. The IBC is sometimes referred to as the "Router Room." The IBC is typically located on the basement or ground floor, away from any electrical rooms.

On the NIH campus two diversely routed paths are required for the LAN backbone connectivity into each building. One path shall be from either the utility tunnels or pnematic tube conduits and the other shall be the telephone company manhole system. At a minimum use two diverse paths in the telephone conduit system. Two 100mm conduits shall be provided to the IBC from each path. All ground installed conduit shall be encased in concrete.

Two 100 mm conduits shall connect the IBC with the first LAN closet(s). Each 100mm LAN conduit shall have three 25mm inner ducts installed with pull lines for present and future use. Between stacked closets, two 100 mm sleeves shall be provided in the floor. The conduits shall terminate 150 mm above finished floor and be sealed to prevent flooding of the closet below.

LAN cable closets and telephone (voice) closets shall have a common wall. The wall shall be constructed floor to floor. The 24-hour maintained temperature shall be 15-35°C in the IBC and LAN closets. Each closet shall have its own thermostat. The relative humidity shall be maintained at 30-60% and be noncondensing. The LAN cable closet shall be 9 m^2 for up to 900 m^2 of area served per floor. The minimum wall dimension shall be 2.4 m long. Closets shall be located such that the maximum run of unshielded twisted pair (UTP) Level 5 EIA/TIA copper conductors is 90 m. Horizontal connections between closets are not required. The closets shall be centrally located and stacked floor to floor. The four closet walls shall be covered floor to 2.4 m AFF with 19 mm thick, fire-retardant plywood primed and painted flat white.

The LAN closet shall be provided with two 20 A individual emergency circuits with individual neutrals. Each circuit shall supply a quad receptacle (two duplexes). The receptacles shall be equally spaced on the long wall 460 mm AFF.

Two-lamp fluorescent light fixtures controlled by a switch at the door are required per LAN closet.

A dedicated ground riser (DGR) of #4/0 AWG bare copper shall be installed continuous through stacked closets. A grounding conductor from the separately derived source serving the receptacles in each closet shall be connected to the DGR. This grounding conductor shall be installed from the transformer secondary or the panelboard ground bus serving the receptacles if the panelboard contains the neutral to ground bonding strap. A ground grid in the IBC shall be provided. The DGR shall be connected to the IBC ground grid. The IBC ground grid shall be connected to the electrical service entrance ground grid in the main electrical room. The ground grid in the IBC shall be similar to the electrical service entrance ground grid; see section E.8, Power Quality. If a lightning protection system is provided, it shall be tied to the IBC ground grid.

Cable tray shall be used in all new installations. The minimum size shall be 300mm wide by 100mm deep. Cable tray shall be installed in all corridors, LAN&IBC, and elsewhere to form a continuous pathway for LAN cables. Cable tray shall be UL listed as a ground conductor and shall be electrically continuous and grounded through approved means. The cable tray shall be of the ladder or center spline style.

A 19 mm minimum conduit shall be installed from the LAN outlet through the corridor wall to the corridor ceiling space for a single work station. Firestopping shall be provided by the conduit installer after the cables are installed. Conduits in fire walls shall be metallic and shall penetrate 150 mm beyond the face of the wall. Flexible metal conduit shall not be used because the insider surface cuts and chafes the data cable. The maximum conduit fill shall be 40% of the conduit area for installations requiring the servicing of more than one LAN outlet from a conduit. Where there are questions of conduit size or quantity, contact the NIH Division of Computer Research Technology/Network Systems Branch.

The documents shall contain the following required coordination: The general contractor shall notify the owner's data wiring subcontractor prior to ceiling installation close-up.

The general contractor shall schedule telecom/LAN wiring prior to ceiling close-up. The general contractor shall allot the required time period to install telecom/LAN wiring. The design documents shall state the time period required.

E.10.1 Telecom

The construction documents shall provide telephone raceway in accordance with EIA/TIA standards. Telephone cable and station wiring shall be provided under a separate contract by the NIH or the user.

The telephone system including FAX data shall be installed in accordance with the LAN infrastructure described above.

Telecommunications (telephone and LAN) manholes shall be numbered similar to electric manholes as described in the Distributed Duct System section, except using the letter "T" in lieu of "E".

E.11 Nurse Call

A nurse call system shall be provided in patient care areas as described in the Clinical Center guidelines. The system wiring shall be installed in conduit.

E.12 Paging

Paging systems are rarely needed at the NIH; however, where deemed necessary they shall follow these criteria. Paging (public address) systems shall be installed in conduit. Paging speakers shall be installed in recessed back boxes. The paging system shall operate at 70 V. The wiring to speakers shall be #18 AWG two-conductor shielded. Paging-speaker sound levels shall consider the ambient noise level. Speakers for ceiling mounting in corridors and other finished spaces shall have multitap transformers with 1/4, 1/2, 1, 2, and 4 W taps. Speakers for use in machine rooms and other high noise level rooms shall be of the horn type with sound outputs at least 3 dB above ambient.

E.13 Television

Some buildings on campus are wired for Cable TV Montgomery. Conduit shall be provided for the installation of the cable by Cable TV Montgomery.

E.14 Security

A card access system exists on campus for building access. The NIH Division of Security Operations must be notified during the early stages of design for card reader approval and design approval.

A 20 A, 120 V circuit shall be provided at each exterior door location to power the door lock system.

The card reader system is maintained by Cardkey Systems, Inc. All final connections shall be performed by Cardkey Systems personnel or an authorized factory-trained technician.

A data cable consisting of two twisted shielded pairs of #20 AWG wire shall be installed from the card reader to the multiplexer located in the nearest telephone room.

Visitors without badges to buildings after hours must call the Police Communications Center to gain access. A telephone conduit shall be provided outdoors at a location designated by the NIH Division of Security Operations for a security telephone.

Emergency phones with blue lights mounted above shall be provided at strategic locations in remote areas, on buildings, in parking garages, and in or near parking lots. The phones connect the caller directly with the Police Communications Center. When a call is answered, the location of the calling phone is automatically annunciated in the Police Communications Center to aid in sending help.

Where the blue-light phones are located in parking lots, they may derive power from the site-lighting circuits. The site-lighting circuits shall not be tapped underground. Site-lighting circuits shall only be tapped in the light pole bases. Stepdown transformers shall be provided to power the blue lights. The appropriate primary voltage shall be provided to match the lighting circuit, with a 120 V secondary. Primary and secondary overcurrent protection shall be provided with the transformer.

The blue lights mounted above emergency phones are there to mark the phone location. The blue light shall consist of a weathertight enclosed and gasketed fixture with a 7 W fluorescent lamp and blue globe.

Coordinate security requirements with door lockset requirements.