Introduction to Electrical Systems for Medical Facilities

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An Introduction to Electrical Systems for Medical Facilities

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CONTENTS

1. GENERAL

This discussion provides an introduction to planning, designing and construction of electrical power and illumination systems for medical and dental treatment facilities (MTF). It is not intended as a design manual.

1.1 Criteria.

1.1.1 Scope. The latest version of the general electrical and illuminating criteria and standards are referenced at Table 9-1. Special electrical criteria, standards and policy for medical facilities are covered in this discussion. Where criteria and standards for general and specific conditions and problems are not covered, acceptable industrial standards shall be followed.

1.1.2 Power Supply Criteria Factors. Facilities are generally classified as essential or support. The designer will verify with the user the facility classification and design requirements to achieve the necessary degree of reliability, durability, maintainability, efficiency, and economy as appropriate.

1.1.2.1 Reliability. Classification and requirements will be used to establish the design reliability requirements. An alternative comparison assessment will be developed to evaluate the reliability choices. Alternative power systems may be authorized, but are limited to serving certain essential loads for critical, hospital, and other special facilities and loads as identified therein. The designer shall consider the location and space for essential electrical system components in order to limit interruptions caused by localized natural conditions, such as floods and earthquakes. Essential systems will be designed to function after seismic events occur. Non-essential systems may be inoperable, but components will be constrained to avoid personnel injury, or damage to other building components.

1.1.2.2 Durability. Installed electrical systems and electrical equipment will have a minimum rating for continuous full design load, except where other criteria mandate greater, to meet the reliability requirements for the design life of the facility.

REFERENCE NO:	TITLE OR DESCRIPTION:
NFPA-30	FLAMMABLE AND COMBUSTIBLE LIQUIDS CODES
NFPA-37	STANDARDS FOR THE INSTALLATION OF COMBUSTION ENGINE AND GAS
NFPA-70	NATIONAL ELECTRICAL CODE
NFPA-99	STANDARDS FOR HEALTH CARE FACILITIES
NFPA-101	LIFE SAFETY CODE
NFPA-110	EMERGENCY AND STANDBY POWER SYSTEMS
NFPA-780	LIGHTNING PROTECTION CODE
ANSI-C2	NATIONAL ELECTRICAL SAFETY CODE
ANSI Y32.2	GRAPHIC SYMBOLS FOR ELECTRICAL AND ELECTRONICS
MIL-HDBK-419	GROUNDING, BONDING AND SHIELDING FOR ELECTRICAL EQUIPMENT AND FACILITIES (VOL I and II)
MIL-HDBK-1013/1A	DESIGN GUIDANCE FOR PHYSICAL SECURITY OF FACILITIES
UFC 3-520-01	***DESIGN: INTERIOR ELECTRICAL SYSTEMS***
UFC-3-600-1	FIRE PROTECTION
IEEE C62.41.91	IEEE RECOMMENDED PRACTIC ON SURGE VOLTAGE IN LOW VOLTAGE AC POWER CIRCUITS
IEEE STANDARD 142	IEEE RECOMMENDED PRACTICE FOR GROUNDING OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS
IEEE STANDARD 241	IEEE RECOMMENDED PRACTICE FOR ELECTRIC POWER SYSTEMS IN COMMERCIAL BUILDINGS
IEEE STANDARD 242	IEEE RECOMMENDED PRACTICE FOR PROTECTION AND COORDINATION OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS
IEEE STANDARD 399	IEEE RECOMMENDED PRACTICE FOR INDUSTRIAL AND COMMERCIAL POWER SYSTEM ANALYSIS
IEEE STANDARD 446	IEEE RECOMMENDED PRACTICE FOR EMERGENCY AND STANDBY POWER SYSTEMS
IEEE STANDARD 493	IEEE RECOMMENDED PRACTIC FOR THE DESIGN OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS.
IEEE STANDARD	IEEE RECOMMENDED PRACTICE AND

Table 9-1 (Part 1)

REFERENCE NO:	TITLE OR DESCRIPTION:
519	REQUIREMENTS FOR HARMONIC CONTROL IN ELECTRICAL POWER SYSTEMS.
IEEE STANDARD 602	IEEE RECOMMENDED PRACTICE FOR ELECTRICAL SYSTEMS IN HEALTH CARE FACILITIES.
IEEE STANDARD 1100	IEEE RECOMMENDED PRACTICE FOR POWER SYSTEM AND GROUNDING SENSITIVE ELECTRONIC EQUIPMENT.
EIA/TIA 568A	COMMUNICATION BUILDING TELECOMMUNICATIONS STANDARD
EIA/TIA 569A	COMMUNICATION BUILDING STANDARD FOR TELECOMMUNICATIONS PATHWAYS AND SPACES.
EIA/TIA 606	ADMINISTRATION STANDARD FOR TELECOMMUNICATIONS INFRASTRUCTURE OF COMMERCIAL BUILDING
(a) HB-9-00	ILLUMINATION ENGINEERING SOCIETY LIGHTING HANDBOOK
UFC 3-400-01	ENERGY CONSERVATION

Table 9-1 (Part 2)

1.1.2.3 Maintainability. The design and construction for facilities will provide a means to remove and maintain equipment, and field installed wiring without interruption to mission critical loads.

1.1.2.4 Efficiency. The efficiency of the facility electrical system, measured at the utilization transformer secondary and the alternative power source, will have a power factor (PF) not less than 0.90 at nominal voltage for balanced three phase loading (phase unbalance will not exceed 5 percent between A, B, and C phase). Where required power factor correction shall be used to assure a minimum PF of 0.90.

1.1.2.5 Economy. Evaluate alternative system configurations, and component types and sizing for economic value, consistent with other criteria factors above.

1.2 Definitions.

1.2.1 Critical Care. NFPA-99 and 70 discuss various minimum safe practices, and safety requirements for "General Care", "Critical Care" and "Wet Locations." The following patient care areas for hospitals have been identified as "Critical Care Areas" where patients may be subjected to invasive procedures and connected to line-operated electromedical devices:

a. Operating rooms.

b. Delivery rooms and Labor and delivery rooms.

c. Cystoscope rooms.

d. Oral Surgery, Maxillofacial surgery, Perodontics, and Endodontics.

e. Recovery (surgery, and labor recovery beds).

f. Coronary care units (patient bedrooms).

g. Intensive care unit (patient bedrooms).

h. Emergency care units (treatment/trauma/urgent care rooms and cubicals).

i. Labor rooms (including stress test and preparation).

j. Intensive care and isolation care nursery.

k. Cardiac catherization.

l. Angiographic exposure room.

m. Hemodialysis (patient station).

n. Surgery suite preparation and hold.

o. Hyperbaric chamber.

p. Hypobaric chamber.

q. Radiation Therapy (including simulator room).

r. Nuclear medicine (camera room).

1.2.2 General Care. All other patient care areas will be treated as "General Care."

1.2.3 Wet Procedure Locations. The area in a patient care location where a procedure is performed that is normally subjected to wet conditions from the procedure while the patient is present, that includes standing fluids on the floor and/or drenching the

work area, either of which condition is intimate to the patient and/or staff. These areas will conform to the requirements NFPA-99, Paragraph 4.3.2.2.8 “Wet Locations” and NFPA-70, Paragraph 517.20, “Wet Locations”.

1.2.4 Wet Locations. Those patient care areas that are normally subject to wet conditions including standing water on the floor, or routine dousing or drenching of work areas and those areas defined in NFPA-99 and 70. Routine housekeeping procedures and incidental spillage of liquids are not defined as wet locations. Operating rooms, delivery rooms, and other similar areas/locations may be a “Wet Procedure Location” as defined by 1.2.3.

2. EXTERIOR ELECTRICAL.

2.1 Exterior electrical systems shall conform to ANSI-C2, "National Electrical Safety Code," except where Service technical criteria have more stringent requirements.

2.1.1 Common Voltages. 4.16kv, 12.47kv, 13.2kv, 13.8kv and 34.5kv are common distribution voltages. However, 12.47kv, 13.2kv, and 13.8kv are the normal distribution voltages serving medical facilities.

2.2 Normal Source Site Investigation. Coordinate electrical utility siting with other utilities. Provide underground distribution on site, and visual screening by location or landscaping elements, where appropriate for the project, to improve overall site aesthetics.

2.3 Normal Hospital Source. For electrical design criteria related to power supply, see documents listed in Table 9-1. Hospitals will be served by two primary service feeders each serving one end of a double-ended substation or to a selector switch serving a multi-ended network substation. Each feeder shall be able to carry the full hospital demand plus 20 percent spare load growth, and shall be installed in an underground concrete encased ductbank within the hospital site. Dual primary feeders serving both

ends of a double-ended substation, through a primary selector switch, must have prior approval of the regulatory authority before incorporation into a design. Service feeders will be connected to different power sources, if available, and to two differently routed distribution system feeders. Where two power sources are not available, the service feeders may be connected to two different sections of a true loop system (A true loop system configuration is where both ends of a utility primary feeder originates from different substations or switching stations, or different breakers and transformers in the same substation and has the capacity to serve the total loop load from either end.). Manually operated primary selector switch and fused load break disconnect switch will be provided for each transformer as indicated in Figure 9-1.

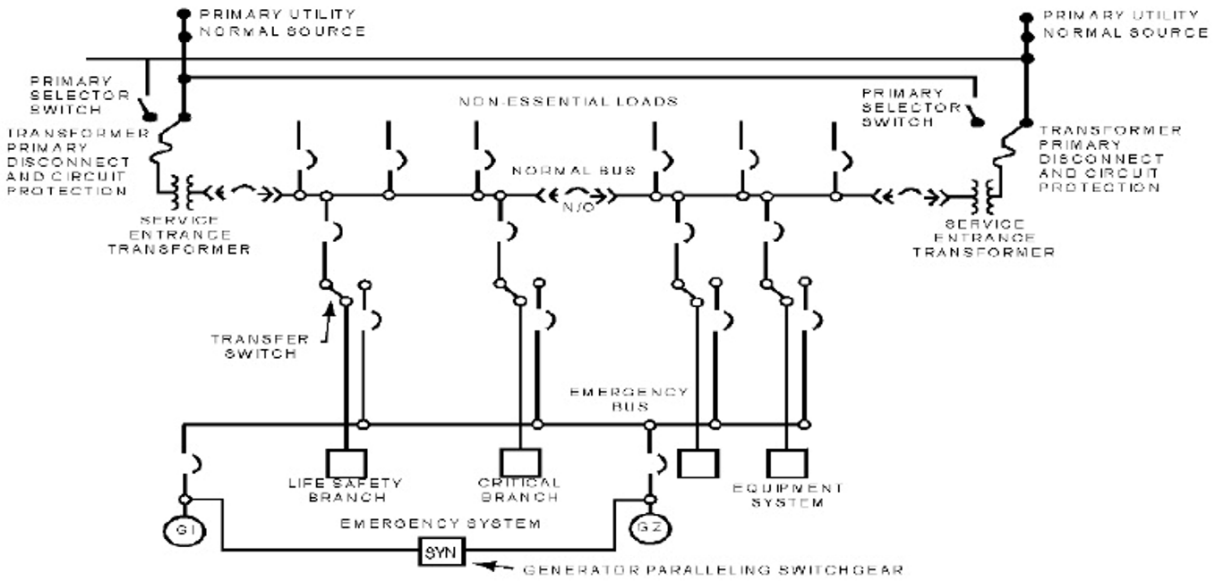

Figure 9-1
Hospital One-Line Diagram

Transformers will normally be located outside the hospital, but may be located within the building where practicable and economical. Double-ended unit substation distribution systems will be designed for hospitals, medical centers and specially designated facilities. The double-ended substation configuration shall be arranged for easy expansion from each end. Each transformer in the double-ended unit substation will be sized to serve approximately 60-70 percent of the substation demand load (linear and nonlinear) before forced air cooling is initiated and 100% of demand load with forced air cooling initiated and will be impedance matched. All double-ended unit substations will have coordinated surge and fault protection. System protection will be selective. The normal power system main equipment shall not be located below finish grade level.

2.4 Normal Ambulatory and Clinic Source. All other health care facilities will be served by a single-ended substation distribution system with coordinated surge and fault protection. The primary service feeder will be designed to carry full demand plus 20 percent spare load growth capacity.

2.5 Transient Protection. Systems that incorporate solid-state devices are susceptible to electrical system transients that can cause system malfunction or equipment component damage. Unless specifically required for specific items of equipment by an A&E (designer) evaluation of solid-state requirements for intensive care areas and approved for installation, power conditioning equipment will normally not be installed as part of the building electrical system at the utilization point. Systems that utilize solid state devices will be provided with transient protection. Static Uninterruptible Power System (UPS) will normally be provided with the equipment and system being served. However, requirement or provisions for UPS will be determined on a project-by-project basis. Provisions for future installed power conditioning equipment will be determined on a project-by-project basis.

2.6 Grounding. System ground shall be adequate for safety and for reliable operation of sensitive Users' and facility equipment. Typical communications system equipment

used in hospitals requires five ohm system ground for proper operation. All grounding systems will be bonded together as required by NFPA 70.

3. ALTERNATE POWER SOURCE.

3.1 Alternate Electrical Source. The alternate electrical source will conform to NFPA-70 and 99 except where Service criteria listed in Table 9-1 have more stringent requirements. Additional load capacity may be provided those hospitals assigned mobilization or mass casualty response missions, or located in an area where extended power outages are frequent. The emergency power source will be designed as a separately derived power source. True RMS metering will be provided for load monitoring.

3.2 Ambulatory Care Centers and Clinics. An alternate power source shall be provided if required by NFPA-99. If an on-site generator set is not required by NFPA-99 and 70, approval must be justified. The justification will address contingency requirements, local power requirements, and safety for human life.

3.3 Medical and Dental Clinic. Where any concentration of inhalation anesthetic or intravenous sedation is used or any electrical life support or resuscitative equipment is used in medical or dental clinics, an alternate source of power is required in accordance with NFPA-70, and NFPA-99. The alternate source of power will be either a generator, battery system, or self-contained battery internal with the equipment and will have the capacity to sustain its full connected load at rated voltage for a minimum of 1 and 1/2 hours. The system will be so arranged that the alternate source of power shall be automatically connected to the load within 10 seconds. The essential electrical system will supply power for task illumination related to life safety which is necessary for safe cessation of procedures and all related anesthesia and resuscitation equipment.

3.4 Hospitals. The alternate power source will consist of two or more engine generator sets designed to provide electrical power for hospital essential electrical systems, plus

20 percent future load growth at 100% demand (Fig 9-1) during the interruption of the normal power supply, as required by NFPA 70 and NFPA 99. Where the essential electrical system load is less than 150KVA, one generator may be considered. The experience level of available maintenance, availability of parts, and factory service will be factored into designs. The generator sets will be of equal capacity and ratings with matched impedance and loss characteristics and designed to carry, in parallel or through priority transfer equipment, the maximum demand load (linear and nonlinear) of the essential electrical system. Motor starting and X-ray unit momentary kva loads will be evaluated when sizing engine generator sets. Parallel operations of the generator sets will be as indicated by Fig 9-1. Automatic load shedding with manual override controls and load shifting capacity will be incorporated in-the-event that one generator fails. Each generator will have the capacity to handle the life safety and critical care demand loads [Hospitals built under the 1971 version of the National Electrical Code (NFPA-70) may have a life support branch that is the second critical branch supplied by a separate automatic transfer switch (ATS).].

3.5 Engine Generator Sets. Engine generator sets for hospitals will be powered by diesel fuel and conform to Table 9-2. The preferred generating voltage is the highest utilization voltage proposed for the facility. Normally 480Y/277 volt, 3-phase, 4-wire system is the highest utilization voltage. Higher voltages may be generated where line losses would otherwise be excessive. The sets will include automatic start-and-stop equipment, solid state battery chargers, fuel storage tanks, audible and visual warning device to alert of less than 4 hours fuel supply, and day tanks and radiators as required. The engine will have a residential type exhaust silencer and will be able to start and assume its full electrical loads within 10 seconds from the interruption of the normal electrical power source. Generator controls will include reverse power relays to prevent generator damage from commercial or on site generators per NFPA-110. If computers are to be operated directly from the emergency generator (not through a UPS or uninterrupted power supply), an isochronous governor is required.

Table 9-2

Continuous and Emergency Rated Diesel-Electric Generator Sets for Medical Facilities

DEFINITIONS:

1. Prime Power Class engines are for use with diesel-electric generator sets expected to provide power on a continuous basis (i.e., in excess of 4,000 hours annually or in excess of 40,000 hours during the initial 10 years of operation) to serve as the sole or primary source of power.
2. Standby Power Class engines are for use with diesel-electric generator sets expected to provide power on a standby basis for a significant number of hours each year (i.e., between 1,000 and 4,000 hours annually or between 10,000 and 40,000 hours during the initial 10 years of operation).
3. Emergency Power Class engines are for use with diesel-electric generator sets expected to provide power on an emergency basis for a short period of time (i.e., less than 1,000 hours annually or less than 10,000 hours during the initial 10 years of operation).

DESIGN APPLICATION:

1. For 50-Hz power the indicated speed limits should be reduced to the nearest synchronous speed for that frequency.
2. Hospital diesel-electric generator sets are normally EMERGENCY POWER CLASS.
3. Hospital diesel-electric generator sets used for co-generation will be Class "PRIME POWER" or "STANDBY POWER".
4. Design and Construction Cost for Co-generation. The cost differential between medical emergency power and co-generation capacity will not be funded with medical project funds.

3.6 Location of Engine-Generator Sets. Generator sets normally will be located in the central energy plant serving the hospital, provided that the plant is located sufficiently close to the structure to minimize line losses and prevent excessive cable runs. When the central energy plant is remote from the hospital structure, generators will be installed in a generator building located adjacent to the structure or within the structure at ground level (along the exterior wall) whichever is more economical. The generator and emergency switch gear rooms will be located at or near the building exterior to facilitate initial installation and removal and replacement of defective equipment and will be provided with 1 and 1/2 hours battery back-up for general illumination. The generator sets and auxiliaries will be arranged and located so minimum facility modifications will be required for future installation or replacement of an additional generator set and auxiliaries. Service entrance transformers *and* other equipment not supporting the essential electrical system will not be installed in the same area (room) as the engine-generator sets. Provide view window in or adjacent to the entrance door. The alternate power system main equipment shall not be located below finish grade level.

3.7 Engine Starting. Electric start will be provided on engine-generator sets rated below 700Kw and either electric or pneumatic start will be provided on engine - generator sets rated 700Kw through 1000Kw. For all engine-generator units rated above 1000Kw, only pneumatic start will be provided. Reference NFPA-99, and 110.

3.8 Manual Test Switches. Manual test switches will be provided for each automatic transfer switch of the essential electrical system. A group of test switches will be provided at a single point in the generator control area and one test switch will be provided with each automatic transfer switch. The two test switches associated with each transfer switch will be wired in series to allow testing at either location. Testing of either individual automatic transfer switches or the entire essential electrical system will be possible. Each test switch will simulate a normal power source failure and automatically cause the engine generator sets to crank, attain rated frequency and voltage, and to transfer associated essential electrical system loads from the normal source to the emergency source. After 30 minutes of operation in the emergency mode,

essential electrical system loads being tested will again be automatically transferred back to the normal source. If for any reason the generator units experience difficulty while in the emergency mode, the load will immediately be transferred to the normal source automatically. During this test run, nonessential hospital loads will continue to be served from normal power supply without experiencing interruption. A manual override switch will be installed that can be actuated to keep essential hospital loads on the emergency source as long as desired. This switch will permit engine generator sets to operate indefinitely beyond the 30 minute automatic transfer restoration time.

3.9 Generator Set Operation. Generator sets will be designed to function essentially as follows: After 30 hertz (cycles) following an interruption of the normal power supply, each generator set will receive the starting signal simultaneously, whereupon each set will automatically crank and attain normal speed and voltage. Voltage for sensing devices to start generator sets will be taken from each phase of the incoming normal power terminal of each automatic transfer switch. The first generator sets to reach preset voltage and frequency conditions will be automatically connected to the emergency bus. System protection will be provided to prevent simultaneous connection of non-synchronized generators to the dead emergency bus. A priority selective device will be provided and programmed or preset to transfer the emergency system loads (life safety and 2 or more critical branches supported from separate ATSs) from the normal bus to the emergency bus within 10 seconds from time of NORMAL POWER interruption. The remaining unit will automatically synchronize with the emergency bus, close the respective generator breaker, and connect the units in parallel for normal operation. After this, the equipment system loads will be automatically transferred to the emergency bus by programmed or preset incremental steps. The equipment system loads will be completely transferred within 45 seconds, based on a priority sequence, after the generator sets are connected in parallel. Should one or more of the generator sets fail to crank or is shutdown for any reason during the operation, the remaining unit will be scheduled to serve only emergency system loads and, if possible, highest priority equipment system loads until the failed unit is energized and connected to the emergency bus. For such a condition, a programming device will shed all or part of the

equipment loads, to keep the remaining generator within its kw rating. If the automatic controls fail, a manual start switch will be provided to override the automatic start of the engine-generator sets so they can be cranked, synchronized and connected on the emergency bus.

3.10 Return to Normal Power Source. Thirty minutes following the return of a stable normal power supply, both emergency system loads and equipment system loads will be automatically transferred to the normal power source. An automatic timer, having an adjustable time range of from 2 to 30 minutes (set at 30 minutes), will be provided to this transfer. Following transfer of the loads, generator sets will continue to run, unloaded, for a period of 15 minutes before shutdown, after which the controls will automatically reset for a new cycle. A manual start switch will override the automatic start of engine generator sets so they can be manually cranked, synchronized, and connected to the emergency bus, if automatic controls fail. Additional manual controls will be provided as indicated elsewhere in this section.

3.11 Automatic Transfer Switches (ATS). All ATSs will be double-throw with draw-out construction. Contacts will have viewing ports for ease of contact inspection. ATSs shall have been UL tested with the main up-stream breaker to assure coordinated withstand compatibility between the ATS and the interruption time of the breakers. Circuit breaker type transfer switches are not acceptable. Each ATS will have indicator lights to identify Normal Power (green in color) and Emergency Power (red in color). All ATSs will be equipped with a load break by-pass isolation switch (The by-pass isolation switch can be initiated with not more than two movements of the hand to either position regardless of the position or condition of the ATS.) to maintain normal or emergency power while the ATS is being repaired or maintained. Load bypass to the ATS's connected source will be achieved with either no load interruption, or a load interruption of not more than 10 (CYCLES) hertz. ATSs feeding high efficiency motors rated 25 horsepower or larger will be provided with an in-phase monitor to prevent an out-of-phase transfer. The in-phase transfer will be achieved without control of the frequency of either power source to prevent excessive motor in-rush current. Use of closed-transition switching for

facilitating essential system testing requires special justification and approval. The by-pass isolation switch for the ATSs serving nonessential equipment can be optional.

3.11.1 ATS and Bypass/Isolation Switch Location. For new inpatient facilities, the ATS and BP/IS equipment shall be in a separate CMU 2-hour fire rated room with direct access from the normal main power equipment room and the alternate power source equipment room.

3.12 ATS and Bypass/Isolation Switch (BP/IS) Testing. Laboratory testing will be conducted on the ATS and BP/IS to be supplied for this facility, or shall have been completed on a previous, randomly selected standard production ATS and BP/IS unit having the same model and capacity as the ATS and BP/IS specified. The overload, endurance, and temperature tests shall be conducted in the following specified sequence:

a. General.

b. Normal Operation.

c. Overvoltage.

d. Undervoltage.

e. Overload.

f. Endurance.

g. Temperature Rise.

h. Dielectric Voltage - Withstand.

i. Contact Opening.

j. Dielectric Voltage-Withstand (Repeated).

k. Withstand.

l. Instrumentation and Calibration of High Capacity Circuits.

m. Closing.

n. Dielectric Voltage - Withstand (Repeated).

o. Strength of Insulating Base and Support.

No deviation from the test sequence will be granted. Approval will not be granted to deviate from the overload, endurance and temperature test sequence.

3.13 Ground Fault Protection Equipment. The essential electrical system will not be provided with ground fault protection devices. The generator circuit breaker and essential electrical main distribution board circuit breaker will be provided with ground fault detection features, when required, to indicate a ground fault and sound an audible alarm but not trip the breaker. Each ground fault alarm sensor level will be activated when the ground fault current is 10% of the breaker rating but not less than 50 amps.

3.14 Remote Alarm Annunciator. A remote alarm annunciator, storage battery powered, will be provided in a location readily observed by operating personnel at a regular work-station. The annunciator will indicate alarm conditions of the alternate power source as indicated in NFPA-99 and 110, and will include as a minimum the following: battery and battery charger malfunction, engine generator run status, engine generator alarms, and less than 3 hours fuel supply in the day tank and 24 hours supply in the main storage tank. A separate audible and visible derangement signal will be provided within the hospital at a location that is continuously monitored. This derangement signal will be appropriately labeled but need not display individual alarm conditions.

3.15 Fuel Storage Tanks. The fuel storage tanks and installations in Hospitals will comply with NFPA-30, "Flammable and Combustible Liquids Codes," and Local, State, and Federal Environmental Protection Agency requirements. The capacity of the fuel oil tank will be sized to the nearest standard size for a fuel storage use capacity of normal usage shall be a 4-day supply at full load. In remote OCONUS locations a 7-day fuel supply (at full load) shall be provided. A 14-day fuel supply shall be required for prime power projects. If underground fuel storage tanks are required, they shall be double wall with leak detection in accordance with the Environmental Protection Agency (EPA) standards. Separate day tanks, with an overflow back to the main storage tank, will be

provided for each engine generator set and will be sized (not less than 4 hours operation at full load) as follows:

50 kW to 100 kW generator: 25 gallon min. - 50 gallon max.
101 kW to 200 kW generator: 50 gallon min. - 75 gallon max.
201 kW to 300 kW generator: 75 gallon min. - 100 gallon max.
Over 300 kW generator : 100 gallon min. - 250 gallon max.

A set of duplex transfer pumps will be provided for each fuel storage tank. Each fuel transfer pump will be sized to accommodate all generators including future set. All electric fuel tank and related fuel transfer pumps shall have power available at all times [Where two critical branch automatic transfer switches (ATS) are available, each of the duplex fuel transfer pumps shall be connected to different critical branch ATSs.]. Provide fuel filtering equipment as recommended for the generators and the local site conditions. Natural gas or comparable gas fuel will not be used as an operating fuel for hospital emergency power generation.

WARNING: Number 2-diesel fuel can be used in lieu of Number 2-heating fuel. However, number 2-heating fuel can not be used in emergencies as a substitute for number 2-diesel unless the flash point is 125oF, cetane number is 40 and the average Btu/gal is 141,800 (See ASTM D975 for more details).

3.16 Loads on the Alternate Source. The alternate power source will have sufficient capacity to supply the essential electrical system of the hospital as outlined in NFPA-70. Avoid oversizing of generator sets such that load banks are needed for testing under load as required by accreditation authorities. Note that operating generators at low loads leads to fouled combustion, and unreliable performance. The essential electrical system consists of two parts: the emergency system and the equipment system. The emergency system will consist of two branches: the life safety branch and critical care branch. The life safety branch shall have no loads connected to it other than those loads

identified in NFPA-70 and 99. The failure of a critical branch component between the area and the transfer switch could render the entire section without power. Supplying a mixture of normal, critical, and even equipment branch power to critical areas is more reliable and is recommended in NFPA-99. The essential equipment system will serve all essential equipment listed in NFPA-70 and 99. Additional loads may be added to the critical branch or equipment system as needed if it improves hospital operations. The power and lighting loads for the following areas will be connected to the critical branch:

a. Operating rooms.

b. Delivery rooms, and labor and delivery rooms.

c. Cystoscopy rooms.

d. Oral Surgery, Maxillofacial surgery, Perodontics, and Endodontics.

e. Recovery (surgery, and labor recovery beds).

f. Coronary care units (patient bedrooms).

g. Intensive care unit (patient bedrooms).

h. Emergency care units (treatment/trauma rooms and cubicals).

i. Labor rooms (including stress test and preparation).

j. Intensive care nursery.

k. Cardiac catherization.

l. Angiographic exposure room.

m. Hemodialysis (patient station).

n. Surgery suite preparation and hold.

o. Hyperbaric chamber.

p. Hypobaric chamber.

q. Special procedure room(s).

r. Pharmacy dispensing.

s. Radiation Therapy (including simulator room).

t. Nuclear medicine (camera room).

3.17 Essential Loads. Essential loads are divided into three categories: Life safety, Critical Care and Equipment. These loads receive both normal and emergency power. However, dual sources of critical power (originating from separate critical branch ATSs) are required in some areas. The following information derives from the current editions of NFPA-99 and NFPA-70; Designer's shall refer to the latest editions of these standards as they become available, and shall coordinate with Table 9-1 for other special communication power requirements.

3.17.1 Life Safety Branch Loads. The life safety branch provides emergency power to ensure patient and personnel safety during the interruption of normal power source. The following lighting, receptacle and equipment limitations are as defined by NFPA-70 and 99:

a. Egress illumination includes 25% of corridor and 50% of stairway illumination, plus 25% of assembly areas such as dining rooms, chapels and auditoriums.

b. Exit signs shall be selected to provide visibility in smoke conditions

c. Fire alarm and piped medical gas alarm systems, including smoke alarms, medical vacuum system alarms and alarms for ventilation for smoke evacuation for those areas where patient evacuation is not feasible.

d. Emergency communications to be used to notify the general population (radio paging and intercom systems), including telephone system, power and lighting for communication closets and crisis control centers, and associated equipment. Various related systems are included as directed.

e. Selected power, task lighting and receptacles at generator set locations; in transformer, switchboard, mechanical and electrical equipment rooms; repair shops and other equipment rooms; and charger for battery powered emergency light sets.

f. Elevator cab lighting, control, communication and signal systems.

3.17.2 Critical Branch Loads. The critical branch of the emergency system alternate power will supply task illumination, fixed equipment, selected receptacles and special power circuits serving areas and functions related to inpatient care during the interruption of normal power. The following are in agreement with NFPA-70 and NFPA-99:

a. Nurse call, telephone equipment and selected computer equipment and selected data outlets.

b. Oxygen and medical gases equipment**,** medical surgical vacuum pumps, and medical surgical compressed air system.

c. In patient rooms (on inpatient nursing units), one duplex receptacle will be provided per bed including mobilization beds located in the patient service console. Two additional wall-mounted duplex receptacles will be provided in single bedrooms and pediatric bedrooms.

d. All receptacles in patient service consoles, isolation nursing rooms, cystoscopy, IVP rooms, cardiac catheterization room, radiographic special procedure rooms, oral surgery room, and recovery rooms. Provide additional normal powered receptacles for backup of critical circuits.

e. All receptacles in selected rooms in the surgery suite, the delivery suite, nursery, coronary care unit, intensive care units, hemodialysis, and emergency.

f. All equipment for the refrigerated storage of blood, biological, pathology specimens and medicines.

g. Two X-ray rooms (including one fluoroscopic room) and required automatic x-ray film processor station.

h. Dental oral evacuation system and dental compressed air system.

i. Laboratories, incubators, analysis, blood bank, bone and tissue banks, chemistry, hematology plus selected receptacles.

j. One flash sterilizer in each surgical suite and delivery suit cluster core.

k. Selected receptacles in admitting and disposition, pharmacy, treatment rooms, nurse stations, and oral surgery rooms, Maxillofacial surgery, Perodontics, and Endodontics clinic treatment areas with central piped medical gas outlets.

l. Medical preparation stations and nourishment stations.

m. Fuel transfer pump, battery charger, jacket water heaters, alarms, controls, air compressors for pneumatic start and other similar generator systems accessories essential for generator operation.

3.17.3 Equipment System Loads. Equipment system feeders and branch circuits connected to the emergency/alternate power source will supply loads automatically in a delayed selective order through automatic transfer switches. The following equipment list derives from the current editions of NFPA-99 and 70; Designers shall refer to the latest editions as they become available.

a. One passenger type and one hospital service elevator per hospital wing (or section if applicable) to operate on a selective basis.

b. Fire pumps and controls will be the first to connect and the last piece of equipment to be shed. The load for fire pumps will be based on the lock rotor current of the motor plus the controls.

c. Refrigeration, food service and morgue refrigeration.

d. Essential power for auxiliaries and controls to provide safe operation of the heating plant.

e. Medical vacuum, waste anesthesia evacuation, and medical air system; dental vacuum and dental air systems emergency power support shall be determined upon a project by project basis in coordination with Using Service requirements and other provisions of this Section.

f. HVAC systems, including cooling *and heating* capacity for all critical care spaces, and heating of patient bedrooms

g. Domestic water, sump and sewage equipment needed to continue hospital operations.

h. Special purpose exhaust systems, hoods in laboratories, including radioisotope hoods, and isolation room exhaust fans.

i. The pneumatic tube system.

j. Helipad lighting and visual navigational aids.

If night operations are required, 10 minutes of battery backup will be provided to obtain no break system and will be connected as a priority-2 load (Where helipad operations are essential, provide a priority 1 equipment connection.).

3.18 Alternate Source Testing. Alternate power source essential electrical systems shall be tested before final acceptance, for proper operation, as required by NFPA 99 and 110. All connected loads will be made operational, and will be operating within normal demand load tolerances. Alternate power systems will be designed to facilitate periodic system-wide and component test and inspection.

4. INTERIOR ELECTRICAL SYSTEMS.

Interior electrical systems shall conform to NFPA codes except where user criteria are more stringent.

4.1 Utilization Voltage. 480Y/277V, 460V, 208Y/120V, 240V and 120V low voltages and 4.16kV and 6.9kV medium voltages are common utilization. However, 480Y/277 volt and 208Y/120 volt are the standard utilization voltages for new and existing medical facilities.

4.1.1 Interior Distribution. Interior lighting and power loads will be served at the highest voltage practicable. Fluorescent and high intensity discharge (HID) lighting systems and building power loads will be supplied by a 480Y/277 volt system. Dry-type transformers will be utilized to furnish 208Y/120 volt power for incandescent lighting,

receptacle, and small equipment loads. These transformers will be "K" factor rated if required for specific non-linear loads (See sample analysis matrix Table 9-4). Where transformer type voltage regulators are used to maintain nominal voltage within plus or minus 5%; an automatic step or induction transformer regulator shall be used which have adjustable high and low voltage limit controls and a voltage meter. A 208Y/120 volt system will be provided where the use of higher voltage is not cost effective. Main distribution switchgear and switchboards will be the draw-out, solid state, adjustable trip circuit breaker. Panelboards for branch circuits will be of the circuit breaker type. Ground fault protection will be provided in accordance with NFPA-70 and 99. All protective devices will be coordinated for selective overload, short-circuit, and ground fault protection. Ground fault protection of the essential electrical system will be as required above.

4.1.2 Coordination and Short-Circuit System Analysis. Short-circuit and protective devices coordination studies shall be undertaken in accordance with recognized authority. Additionally, a coordinated protective devices setting will be provided by the designer. Selection of protective devices and switchgear for a new electrical system shall be based on a short-circuit protective device coordination analysis. For additions or modifications to existing system, the analysis shall include all of the protective devices affected in the existing system. All protective devices shall be properly coordinated to provide selective tripping. No, series rated protective equipment and/or devices will be allowed! Surge protection should also be incorporated in the coordination analysis.

4.1.3 Location and Space Requirements. Electrical equipment rooms will be located at or near the building exterior to facilitate initial installation of large equipment, and removal and replacement of defective equipment. Adequate space will be provided for maintenance of electrical equipment and equipment removal. Pipes and other equipment foreign to the electrical equipment will not be located in, enter, or pass through such spaces or rooms. Where practicable in finished areas of hospitals, panelboards, signal and communication cabinets will be grouped, surface-mounted, in

separate electrical and communication ventilated wiring closets. Joint use closets are not acceptable and will not be provided. Closets in which dry-type transformers and automatic transformer type regulators are installed, should be located away from noise sensitive areas and provided with adequate ventilation to maintain an ambient temperature not to exceed 86 degrees F. For hospitals with more than one floor, electrical and communication closets should be stacked vertically whenever practicable. Panelboards in critical care areas will be located in the vicinity of their loads, and will be accessible to the operating staff only. Such panelboards will not be located in the patient bedrooms.

4.1.4 Electrical Rooms. A minimum of one branch circuit electrical room shall be provided for each smoke zone of a hospital building space, and each 2090 square meter (22,500 square feet) of other medical facilities building space. The footprint for each piece of equipment with working space, and NFPA-70 clearance requirements shall be shown. No branch circuit electrical room will feed loads beyond the smoke zone in which it is located. The branch circuit electrical rooms will be accessed off of a primary through corridor, and the entry door or doors will swing 180 degrees as not to impede traffic flow in the corridor or violate clearance requirements of NFPA-70. In multi-story medical facilities, the branch circuit electrical rooms should be stacked. A minimum of 20 percent additional free wall space should be provided to accommodate customer flexibility requirements.

4.2 Conduit, Cable Tray and Wire. All wiring will be insulated copper in conduits and installed per NFPA-70. Metal enclosed feeder, plug-in busways or surface metal raceway may be used. A green insulated copper ground conductor will be run with all branch circuits. Wiring in all patient care areas and the life safety branch and critical branch of the essential electrical system will consist of insulated conductors installed in a separate metallic raceway. Where cable trays are used the normal and essential power system conductors will be in separate full height compartmented, and electrically continuous covered trays. Cable and raceway circuit identification shall be at each end and at all transitions.

4.2.1 Conductors installed to furnish emergency power will not be installed in the same raceway with normal power conductors.

4.2.2 All normal and emergency power junction boxes, pull boxes and similar parts will be readily accessible. Clearly identified access panels will be installed as necessary for proper maintenance and operation of the electrical distribution system.

4.3 Branch Circuits. All circuits serving patient care areas shall comply with NFPA-99 and 70 except where reference criteria requires more stringent standards.

4.4 Wet Treatment Areas. Circuits serving "wet" treatment locations will be furnished with ground fault interrupters. Ground fault interrupters on circuits serving life support equipment will not be installed, as required by NFPA-99 and 70.

4.5 Radiology Provisions.

4.5.1 X-Ray Feeder. Radiographic or fluoroscopic equipment will be supplied by a 3-phase, 5 wire neutral and ground, 480Y/277 volt feeder from the main distribution switchboard to an enclosed circuit breaker disconnect located adjacent to the associated X-ray control room. X-ray loads will not be included in the demand load. Effect of X-ray unit momentary kVA load on transformer voltage regulation will be evaluated. Transformer size will be increased as necessary and feeders sized for satisfactory system performance. Separate service transformers to the X-ray units will not be provided. A door interlock system will be provided to prevent production of X-rays when any X-ray room door is open. Magnetic type door switches, and conduit and wiring from the switches to the control console will be provided. Doors immediately adjacent to the control room may not be required to be part of the interlock system. A single phase 120/208 volt branch circuit panelboard will be provided in each room for X-ray unit peripheral equipment. Additional electrical design requirements are contained in

the (Universal) x-ray room criteria portion of the Section Medical and Dental Equipment and Appendix "B”.

4.5.2 Mobile X-Ray Unit Outlets. Mobile X-ray equipment in nursing units will normally be battery operated. Duplex receptacles rated 20-ampere, 125-volt for battery recharging will be provided in designated areas. Should battery operated units not be used as determined by the Using Service, each nursing unit corridor will be provided with 60-ampere, 250-volt, 2-pole, 3-wire, single phase, twist lock, grounding type flush mounted receptacle. Mobile X-ray unit loads will not be included in demand load.

4.6 Receptacles. Receptacles will be provided as follows.

4.6.1 General Purpose Receptacles. General purpose multi-outlet branch circuits will be rated 20-amps with convenience straight blade type receptacles rated 20-ampere, 125-volt, 2-pole, 3-wire, grounded type. All other receptacles including those dedicated to medical equipment will not be of less than 20-ampere rating. Receptacles will normally be straight blade type. Provide a minimum of one general purpose 20-amp, 125 volt duplex receptacle outlet per wall in each room. In rooms where walls exceed 3 meters, provide an additional duplex outlet for each additional 3 meter of wall space fraction there of. Receptacle spacing shall not exceed 3.5 meters. The general purpose receptacles are in addition to the special purpose and dedicated outlets for special equipment. Do not provide receptacles in public toilets, staff toilets outside of the command areas and janitor closets.

4.6.2 Hospital Grade Receptacles. Hospital grade receptacles will only be provided where required by NFPA-70 and as defined below. Final design electrical drawings will indicate "Hospital Grade" (HG) receptacles in the following locations Provide Specifications Grade Heavy Duty receptacles in all other locations:

1. General care patient bed locations.
2. Critical care patient bed locations.

3. Any location where a patient bed or patient care service console is located.

4. Anesthetizing locations:

(1) Operating Rooms.

(2) Delivery Rooms.

(3) Oral surgery.

(4) Cystoscopy (in Operating rooms and Clinics).

(5) Cardiac Catheterization Lab.

(6) Angiography / Special Procedures.

(7) CT Scanning Room.

(8) MRI Scanning Room.

(9) Medical Maintenance.

(10) Intensive Care.

(11) Emergency Trauma Rooms.

(12) Fluoroscopy Rooms.

(13) Endoscopy Rooms.

(14) Pulmonary / Respiratory Therapy.

(15) Nuclear Medicine.

4.6.3 Duplex Receptacles. Not less than one duplex receptacle will be provided in each wall of all rooms and interior areas, except closets, scrub rooms, toilets and similar spaces. Electrical closets will be furnished with not less than one duplex receptacle from a dedicated 20 ampere, 125 volt branch circuit. Communication closets will be furnished with 20 ampere, 125 volt duplex receptacles on each wall and power will be supplied by two dedicated 20 ampere branch circuits on the same phase. One duplex receptacle will be provided per every 3 linear feet of casework in nurse's stations, subnurse's stations, reception counters, and control counters. Each administration type desk location will be provided with two duplex receptacles. Each data workstation will be provided with an additional identified duplex outlet. Each data outlet device plate will be marked "data power" with a steel stamp or silk screened 1/4 inch high letters. Circuits

for data outlets will be an independent single phase 20 ampere, 125 volt circuit serving not more than four duplex receptacles and having a non-shared neutral. Where a 20 ampere, 125 volt receptacle is incorporated in the same metal box with a television or data outlet, a partitioned metal box with separate power and signal conduits will be provided as required (Criteria can be found in Section 10, "Communications."). See Guide Plates for requirements in special areas.

4.6.4 Safety Receptacles. Hospital Grade tamper resistant receptacles will be provided in all hospital areas occupied by children, including playrooms, baths, toilets, pediatric waiting and pediatric bedrooms. Receptacles in psychiatric seclusion rooms (patient care areas, wards and rooms) will also be of the hospital grade tamper resistant type. The safety receptacles used in these areas will be designed to prevent shock hazards from metallic objects which might be inserted in the receptacle slots.

4.6.5 Maintenance Receptacles. Floor maintenance receptacles located in corridors will be flush mounted and will not be of less than 20-ampere rating. Determination of receptacle type, voltage, current rating, and spacing will be coordinated with the Using Service to provide the best utilization of existing floor maintenance equipment. Provide receptacles within 7 meters (25 feet) of all installed equipment which requires maintenance.

4.6.6 Back-to-Back Receptacles. Outlets installed back-to-back through walls will be permitted only in rooms or areas where sound control or fire rating integrity is not required.

4.6.7 Receptacle Identification. Receptacles connected to the emergency system will be red and may be furnished with either metal or plastic plates. Metal plates will be finished in baked enamel and acrylic plastic plates will be impact resistant with integral color. Each device plate will be marked "EMERGENCY" and will identify the panelboard and circuit number at the top with steel stamped or silk screened letters not less than 1/4 inch high Indentation of the steel stamp will be filled with black enamel or acrylic

paint. Silk screened letters will also be of black enamel or acrylic paint. Pressure sensitive tapes with markings are not acceptable.

4.6.8 250 Volt Receptacles. All 250 volt receptacles will be furnished with matching plugs.

4.6.9 Ground Fault Circuit Interrupters (GFCI). Hospital Grade Class "A"GFCI receptacle protection will be provided at locations required by NFPA-70 and "WET" locations. GFCI "WILL NOT BE PROVIDED" on circuits serving critical life support equipment.

4.6.9.1 Wet Locations. Those areas that are normally subject to wet conditions, including standing water on the floor, or routine dousing or drenching of the work area are classified as a wet location. Routine housekeeping procedures and incidental spillage of liquids do not define a wet location. GFCI receptacles will be used in the following locations:

1. Hydrotherapy.
2. Therapeutic pool areas.
3. Toilet areas with showers.
    (a) Staff lockers with toilet areas.
    (b) Patient toilet bathrooms.
4. Showers.
5. Staff lounges with kitchen facilities.
6. Outdoor receptacles.
7. Other locations required by NFPA-99 and 70.
8. Receptacles accessible from a building roof.
9. Crawl spaces.

4.6.9.1 Damp Locations. Damp locations are functional areas infrequently using liquids in operational activities and housekeeping procedures but require special attention such as Toilets, Locker areas which are adjacent to showers areas, Sub-sterile and Scrub areas to Surgery and Delivery and so forth. GFCI receptacles are not required.

4.6.10 Patient Bedrooms. Critical care patient bed locations will be provided with a minimum of eight identified duplex receptacles, and general care patient bed locations will be provided with a minimum of four duplex receptacles. Receptacle adjacent to the wash basin in patient bedroom toilets shall be provided with ground fault circuit interrupter protection for personnel. All receptacles will be hospital grade.

4.6.11 Renal Dialysis Units. Two identified hospital grade receptacles shall be provided on each side of the patient bed or lounge chair. Provide one or more normal and emergency critical branch powered receptacles.

4.6.12 Nurseries. Each intensive care nursery provided with 16 simplex receptacles. Each intermediate care nursery will be provided with eight simplex receptacles. Each nursery in admission, observation, and continuing care will be provided with four simplex receptacles. Normal care nurseries will be provided with one simplex receptacle. Receptacles will be 20-ampere, 125-volt, 2-pole, 3-wire, straight blade, grounded type. Floor mounted receptacles will not be used. Ceiling mounted receptacles or groups of receptacles should be considered for nursery locations not adjacent to a wall or column. A minimum of one 60-ampere, 250-volt, 2-pole, 3-wire, twist lock, grounded type, flush mounted receptacle for mobile fluoroscopy unit will be provided in each nursery.

4.6.13 Operating Room and Delivery Room. Each operating and delivery room will be provided with 36 simplex or duplex receptacles, 12 in each service column, and six on each wall mounted 900 mm (3 feet) above floor. Receptacles will be 20-ampere, 125-volt, 2-pole, 3-wire, straight blade, grounded type. Each operating and delivery room will also be provided with one 60-ampere, 250-volt, 2-pole, 3-wire, twist lock, grounded-type flush mounted receptacle for mobile fluoroscopy unit or laser photo coagulator.

4.6.14 Laboratory Receptacles. Above laboratory benches, 20 ampere duplex receptacles will be strip mounted 18 inches on center. Install strips of multi-outlet assemblies above laboratory bench countertops, with 20-ampere duplex receptacles placed 500 mm (18-inches) on center, or closer. Adjacent duplex receptacles will be connected to different circuits and not more than two duplex receptacles will be connected to each circuit.

4.7 Patient Care Grounding. General care areas and critical care areas including all anesthetizing locations will be provided with a grounding system as required by NFPA-99 and 70. Grounding system design and initial testing will be included in the contract documents.

4.8 Inhalation Anesthetizing Location. All inhalation anesthetizing locations will be classified and designed as a nonflammable inhalation anesthetizing location. Operating rooms, delivery rooms, oral surgery, cardiac catheterization and other special procedure rooms are not considered wet areas. Isolated power systems will not be provided except for areas designated as critical care wet areas by the user. Ground fault circuit interrupters will not be provided. Design will conform to the requirements of NFPA-70 and 99. Each operating and delivery room will be provided with two three phase panelboards located within the room. Each panel will be fed from a separate critical branch subpanel and whenever practicable from separate critical branch automatic transfer switches. Panels will be connected to the same phase. Grounding in inhalation anesthetizing locations will be in accordance with paragraph "Patient Care Area Grounding" above.

4.8.1 Flammable Anesthetizing Location. Flammable anesthetizing locations may only be used for training in major teaching medical centers and only after approval by the regulatory authority, user and owner.

4.9 Electromagnetic Shielding for Medical Instrumentation. Designated areas of hospitals and health research laboratories may require electromagnetically shielded

enclosures. The degree of the attenuation required for the enclosure will be based on the manufacturer's recommendation for the instrumentation to be used in the designated space. Shielded enclosures will conform to the requirements of MIL-E-8881. Final design will specify the type of enclosure and the class of attenuation required. When shielded enclosures are not provided, other measures will be taken to limit RFI and EMI in rooms which contain sensitive medical equipment, including the EEG room and electron microscope room. Incandescent lighting fixtures will be used. Rooms will not be located near or directly above or below electrical equipment or mechanical rooms. High voltage feeders will not be routed in the vicinity of these rooms.

5. LIGHTING.

5.1 Design. Lighting design will conform to the requirements of these standards. Electronic ballast are not recommended in areas of medical facilities where electronic (life support) medical equipment is used or areas where invasive procedures are performed, due to possible interference with the equipment. Some examples are operating rooms, delivery rooms, laboratories, special procedure rooms, MRI areas, Medical equipment repair and test areas and other areas of similar use. In no instance shall the lighting footcandle level exceed plus 10 percent for 538.7 Lux (50 footcandles) and plus 53.8 lux (5 footcandles) percent for lower levels. Emergency egress lighting will conform to the requirements of NFPA 101, and the exit signs will conform to the following requirements:

a. Stencil faced exit signs are recommended.

b. The transilluminated letters will normally be red except where state or country standards mandate green.

c. The contrast level of the letters shall be symmetrical with not less than a 0.7 value, plus or minus 5 percent.

d. The lumination output for normal and emergency mode will be not less than 70 cd/sq m. measured across the face of the sign.

e. The surface finish shall be a matte texture.LED exit signs must meet the above performance criteria and carry a manufacturer’s certificate of compliance.

Lighting design and switching will incorporate energy efficient features whenever practicable and consistent with lighting criteria and the functional/operational intent of the hospital. Fluorescent lighting will be provided to the maximum amount practicable, except that infrequently used small storage spaces and janitor's closets may be provided with incandescent fixtures. Exterior lighting will normally be high pressure sodium vapor fixtures. Recessed fluorescent fixtures will be provided in rooms with lay-in acoustical tile ceilings. Fluorescent fixtures may be recessed or surface mounted in rooms with gypsum board on plaster ceilings. Industrial type or open strip type fluorescent fixtures will generally be used in rooms with unfinished ceilings. Fixtures in large storage/supply rooms will be mounted to readily permit relocation within several feet. Fluorescent lamps will normally be 34/40 watt energy saving or 32 watt T8, cool white type, except that 32 or 40-watt chroma 50 type color corrected lamps may be used. Normally, 32 or 40-watt lamps on dimming circuits will be provided as required and as indicated herein. Lighting fixtures with color improved lamps will be identified for lamp replacement by an appropriate marking on the fixture reflector. Marking should indicate lamp replacement with the actual design lamp by name only and should not be visible through the fixture lens. Fluorescent lamps of the U-Tube type should not be used. Use of HID fixtures in patient care areas is not permitted.

5.2 Battery Operated Lighting. Fifteen to 25 percent of the general lighting in the operating rooms, obstetrical delivery rooms, emergency treatment rooms, cystoscopy, and cardiac catheterization rooms, and any other room with invasive procedures will be provided with 1 and 1/2 hour battery backup for general illumination which will operate without interruption during periods of normal and emergency power lapse (These fixtures will be fully illuminated when on battery backup or UPS, and providing not less than 500 lux of illumination in the room. All permanently installed surgical task light fixtures will be provided with no-break power to bridge the power interruption between

loss of normal power and the transfer to emergency power. Batteries for lights in operating and delivery rooms will be located outside those rooms. Fifteen percent of lighting in nurseries will be provided with 1 and 1/2 hour battery backup. Battery capacity may be reduced to 1/2-hour illumination if backed-up by two or more emergency generators. A minimum of 1 battery powered light will be provided in the generator set and emergency switchboard location and central communications room.

5.3 Patient Bedrooms. In patient bedrooms, one wall mounted direct/indirect lighting fixture or a medical wall module system, with lighting features as described herein, will be provided at each bed. Each unit will include upward directed fluorescent lamps for general illumination and downward fluorescent lamps for patient use. The upper fluorescent lamps will be controlled at the door and at the wall unit with a three-way switch. The lower fluorescent lamps for each patient's use will be switched at the bed. All switches will be of the quiet-operating type. Use of low voltage switching utilizing the nurse call handset will be considered. Night-lights mounted in the patient service console will be provided at each bed and will be photo cell controlled and manually controlled at the corridor door.

5.4 Other Rooms. Fixtures in nurseries, surgery, obstetrical suites, emergency treatment rooms, examination rooms, and laboratories will be recessed fluorescent type. Nurse station lights will be switch controlled to achieve 33, 66, and 100 percent illumination levels. Corridor lights adjacent to intensive care bedrooms and nursing unit will be one-third increment switch controlled. In recovery rooms, coronary and intensive care units and X-ray therapy rooms, where patients may be in a supine position for extended periods, low-brightness diffused lighting will be provided. For examination purposes in intensive care units, isolation rooms, single patient bedrooms, labor rooms and recovery, a four-lamp fluorescent lighting fixture, operated by a conveniently located switch, will be provided above each bed. Fixtures in seclusion rooms will be of the recessed incandescent type, of tamperproof construction with impact-resisting tempered lenses. Seclusion rooms will be provided with tamper resistant incandescent night-lights. Darkrooms will be provided with an incandescent photographic safelight in

addition to the normal white light for general room illumination. The safelight is normally considered an item of medical equipment. The "darkroom in use" light, located outside and above the darkroom door, will be controlled by the switch which controls the safelight in the darkroom. The "darkroom in use" light is not required at light-tight type doors. For darkrooms with film loading bins, bin drawers will be interlocked with darkroom white light and safelight so that when a bin drawer is opened, white light is extinguished and safelight remains lit. X-ray rooms will be provided with indirect lighting. The location of X-ray room lights must be coordinated with X-ray equipment. Therapeutic X-ray rooms will be provided with an "X-ray In-Use" light, located outside and above each door. The "X-ray In-Use" light will be controlled by the X-ray unit on-off line power controller. Conduit and wiring from the "X-ray In Use" light to the X-ray unit control console will be provided. Diagnostic X-ray rooms will not be provided with "In-Use" lights. Electroencephalogram rooms will be provided with dimmed incandescent fixtures.

5.5 Dental Clinic. Ceiling mounted fluorescent lighting fixtures will be symmetrically arranged within all finished areas except open dental operatories. In such operatories, fixtures will be concentrated above the dental chairs. Lighting intensities at the working surface in each dental operatory will be not less than 1076 Lux (100 footcandles) nor more than 1614.4 Lux (150 footcandles) with a minimum of 2 level switching circuits. Where color matching is a critical function, such as in the prosthetics laboratory and dental treatment rooms, color improved fluorescent lamps will be specified.

5.6 Exterior Signage. Exterior signage for "EMERGENCY SERVICES" will be stencil-faced with red transilluminated letters, and will be readily visible, identifiable, and legible at all entrance drives. The contrast level of illuminated signage shall be symmetrical and not deviate more than plus or minus 5% percent. Signage for facilities having after-dark operations will have transilluminated letters indicating the facility name. Illuminated signs will be designed for rapid replacement (time not to exceed 15 minutes). Sign location will be coordinated with illumination of access roads, parking areas, and building entrances to minimize requirements for additional illumination of signage.

5.7 Parking Areas and Walks. Normal site areas, including handicap areas, intended for night use will be illuminated by an average of 10.76 Lux (1 footcandles), measured on 1 foot intervals of incident light on the area served. Parking areas will be illuminated with high pressure sodium fixtures equipped with lamps with dual restrike elements, or high pressure metal halide fixtures and lamps where base standard.

5.8 Dimming. Eye lane and eye examination room and group therapy observation room illumination will be furnished with recessed fluorescent fixtures and dimmable incandescent fixtures. Switches and dimmers for eye lane and eye examination room will be located close to the examination chair. Maximum footcandle level in group therapy observation room with respect to footcandle level in group therapy (mirror) room should not exceed manufacturer's recommended ratio for one-way mirrors utilized. Fluorescent general lighting in fluoroscopic and radiographic special procedures rooms will be dimmed at the control stand or at the door entrance, as required.

5.9 Ultraviolet Filters. UV filters shall be provided in infant care areas to prevent retina damage to premature infants and other areas where cataracts are of a major concern. Indirect lighting in premature infant areas shall be provided for all new construction.

5.10 Maintenance Area Lighting. Interior utility tunnels and walk-in pipe chases will be illuminated by one footcandle of incident light for the safety of maintenance personnel. Switches for these lights will be equipped with pilot lights and located in areas that are normally occupied. Receptacles for temporary work lights will be located at reasonable intervals.

5.11 Auditorium. The down light fixture over the podium will be controlled from the podium and the entrance.

5.12 Helipad Lighting, Marking and Controls. Where helipad lighting is required for night operations in visual meteorological conditions (VMC), the lighting will be designed

to ANNEX A criteria Perimeter, limit, floodlights, glide slope indicator, wind-indicator and rotating beacon aviation lighting systems will be incorporated into the design. When marking the helipad for day time operations retroreflective paint markings will be used. Lighting will be connected to the essential power supply.

6. LIGHTNING PROTECTION. Facility lightning protection requirements will be assessed per NFPA-780. Where lightning protection is required; a UL Master Labeled System shall be installed.