

ENGINEERING GUIDELINES



5. ENGINEERING GUIDELINES

1.1 Introduction

The objective of these guidelines is to establish a set of standards and rules that should be adopted by design professionals in preparing tender documents of future construction works at the AUB and provide outline specifications for equipment. The works shall cover new buildings and additions or refurbishment of existing buildings in realizing the Master plan for the AUB.

The design guidelines shall guarantee that the implemented works have an appropriate quality standard, incorporate a unified set of codes, reflect the requirements of the University, and consequently bring about a sense of coherence to the Campus.

1.2 Contents

This engineering guidelines document comprises three chapters for the major systems:

- Power & Communications
- Conveying Systems: Elevators
- Mechanical Works

For each system the document includes the applicable:

- Design criteria,
- Regulations and standards and
- Outline specifications of equipment.

1.3 Design Deliverables

Electrical and mechanical systems shall be designed for reliability, safety, functionality and energy conservation.

Electrical design documents shall include:

1. Drawings for:
 - Graphical symbols, legend and general notes
 - Floor plans showing lighting, power and low current systems layouts - each presented separately,
 - Layout plans for power and low current distribution network showing details of connection to campus utilities. In addition, layouts for the fire alarm and detection system shall be presented separately,
 - Outdoor lighting layout,
 - Schedules of main distribution boards, distribution panel boards, final branch panel boards, motor control centers and feeders, utilizing AUB standard forms,
 - Specifications of lighting fixtures and schedules of lighting control systems,
 - Power, communications and signaling systems riser diagrams and schematic diagrams,
 - Layouts and details of main electrical rooms: transformer room, switchboard room, communication room, generators room,
 - Lightning protection and grounding systems installations and details
 - Conduit and/or cable routing layout and miscellaneous installation details

2. Calculations for:

- Lighting
 - Ampacity tables and cable sizing
 - Load estimate and transformer sizing
 - Generator sizing
 - Voltage drop and short circuit analysis
 - Feeder sizing and protection of large equipment such as chillers and fire pumps
 - Fire alarm voice evacuation system
 - Ventilation, noise and fuel consumption of generators
 - Lightning risk assessment
 - Traffic analysis
 - Other calculations and analyses that assist in design verification and as requested by the Facilities Planning and Design Unit.
3. Specifications (to CSI format) and
 4. Bill of Quantities (BOQ) with one fair priced estimate copy.

Mechanical design documents shall include:

1. Plumbing drawings for:
 - Graphical symbols, legend and general notes
 - Floor plans showing sanitary drainage, rainwater drainage, water supply, hot water distribution, medical gases, fire fighting systems, etc.
 - Schematic and riser diagrams of all of the above,
 - Layout plans for water distribution network, fire fighting system, irrigation system, sewage system, fuel storage etc. showing details of connection to campus utilities

- Equipment performance schedules,
 - Layouts and details of mechanical plant rooms
 - Control diagrams
 - Miscellaneous installation details
2. HVAC drawings for:
- Graphical symbols, legend and general notes
 - Floor plans showing ductwork and piping.
 - Schematic and riser diagrams of piping systems including chilled water, etc.
 - Equipment performance schedules,
 - Layouts and details of mechanical plant rooms
 - BACnet and control diagrams
 - Typical sections and miscellaneous installation details
3. Calculations for:
- Ratings of equipment including pumps, chillers, cooling towers, boilers, heat exchangers, hot water storage tanks, water treatment equipment and other systems
 - Cooling and heating load
 - Pipe sizes, such as hydraulic calculations
 - Duct weight
 - Static pressure for air handling units and fans
 - Ventilation
 - Fuel system sizing
 - Sump pits sizing
 - Rain water
 - Gas tanks sizing
- Other calculations and analyses that assist in design verification and as requested by the Facilities Planning and Design Unit.
4. Specifications (to CSI format) and
5. Bill of Quantities (BOQ) with one fair priced estimate copy.
- Design documents shall be as detailed as necessary to interpret the design, avoid conflicts with other utilities during construction and ensure that the project is implemented in accordance with the University requirements as envisioned in the Master plan. In this effect, provide composite drawings and details for all utilities in order to define the areas and zones where a possible conflict may arise. Provide also Utility Disposition plans and sections for project site area.
- Drawings shall conform to AIA standards for CAD drawing layers.
 - Specifications shall be to CSI format.
 - Buildings shall be supplied with Campus Utility Services including electrical, telephone, data, fire alarm, water supply, steam, etc. All utility services shall be installed underground. Verify point of connection with the Facilities Planning and Design Unit/Physical Plant.

POWER AND COMMUNICATIONS

2.1 Regulations And Standards

- Power supply shall conform with the local power authority (EDL) practices,
- Power supply and distribution shall comply with NFPA 70 "National Electrical Code- (NEC)" where not in contradiction with the local regulations.
- In addition, electrical works for projects related to the Medical Center shall comply with the "IEEE Recommended Practice for electric systems in health care facilities" and NFPA 99 "Standard for Health Care Facilities".
- Nominal characteristics of all equipment forming part of the electrical works shall be specified to conform with the International Electro-technical Commission (IEC) Standards or to the National Electrical Manufacturers Association (NEMA) Standards. In general, all medium voltage network components shall comply with the relevant IEC standards. Low voltage equipment shall be UL listed and conform to approved American standards, except for particular equipment that shall conform to local practices where specified elsewhere in this document. In general:
 - Equipment and materials that shall have to conform to IEC Standards include: Medium Voltage installations (switchgear, power transformers, MV cables, etc.), Low Voltage cables and industrial power receptacles.
 - All other equipment and materials shall be Listed and Labeled as defined in NFPA 70 Article 100, and marked for intended use.
- Standby power supply shall conform to NFPA 110, " Standard for Emergency and Standby Power

Systems" and/or ISO 8528 Part 1: "Reciprocating Internal Combustion Engine Driven Alternating Current Generating Sets - Part 1: "Application, Ratings & Performance ",

- Fire pump cabling shall conform to NFPA 20, "Standard for the Installation of Stationary Pumps for Fire Protection",
- Lighting installations and levels shall conform to the Illuminating Engineering Society of North America IESNA " Lighting Handbook-Reference & Applications" and the American Society of Heating, Refrigerating And Air-Conditioning Engineers ASHRAE 90.1 "Energy Standard For Buildings Except Low Rise Residential Buildings",
- Life safety systems, illumination and marking of means of egress shall conform to NFPA 101, " Code for Safety to Life from Fire in Buildings and Structures ",
- Fire alarm system shall be in accordance with NFPA 72, "National Fire Alarm Code" and NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems",
- Lightning protection system shall be designed to comply with NFPA 780, " Standard for the Installation of Lightning Protection Systems,"
- Telephone installations shall comply with the local PTT requirements and the relevant CCITT recommendations,
- Voice and data wiring installations shall conform to ANSI/TIA/EIA-568-A, " Commercial Building Telecommunications Cabling Standard",
- Installations of miscellaneous wiring devices such as receptacles and switches shall meet the requirements of ADA "Americans With Disabilities Act."

2.2 Electrical Service And Distribution System

2.2.1 System Description

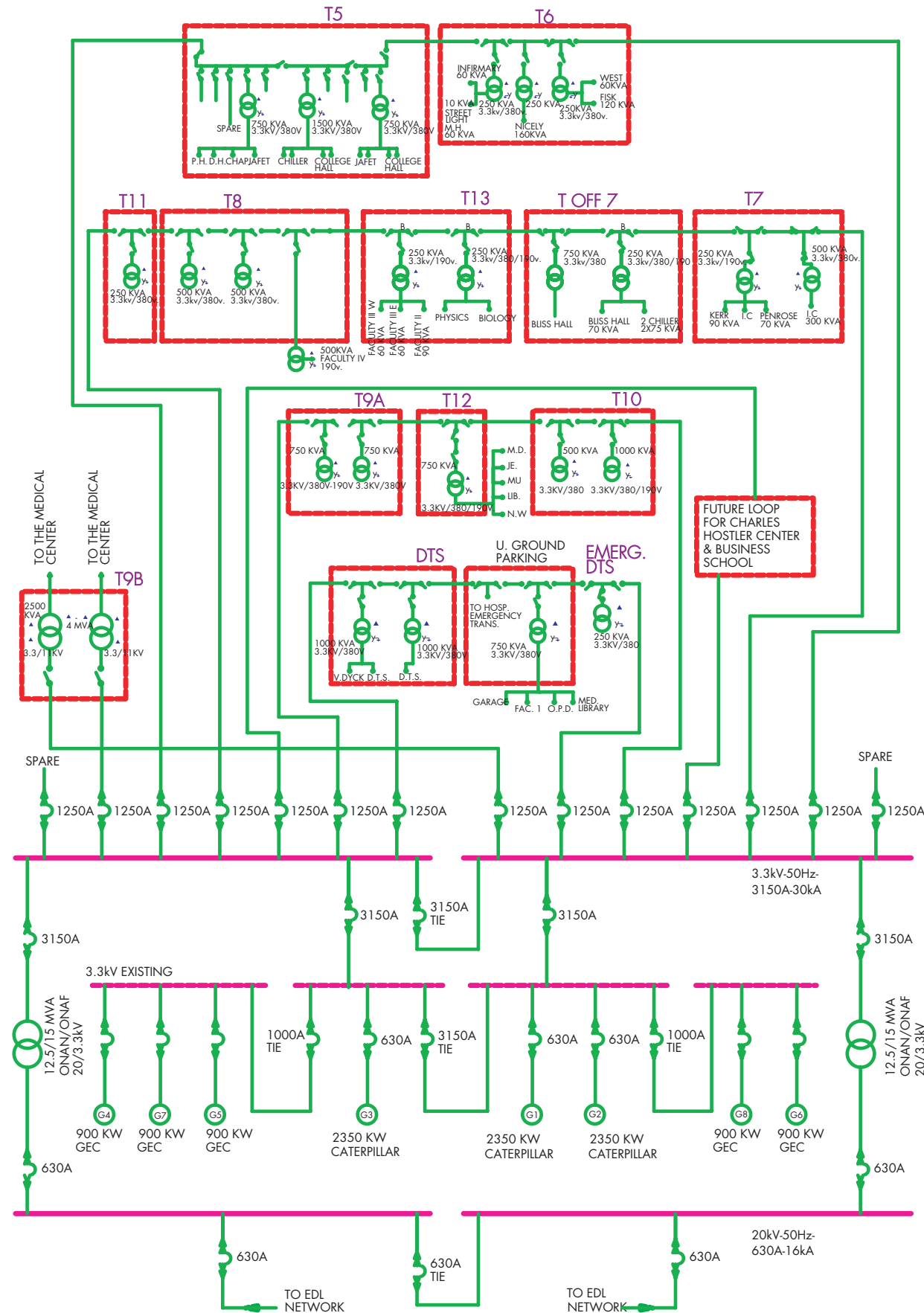
The source of electrical distribution network of the AUB campus is the Power Plant. Here part of the power is generated locally and the other part is derived from the Utility Company EDL. Distribution throughout the campus occurs at the Medium Voltage level of 3.3kV.

The Physical Plant is responsible for operating and maintaining the University local power generation and distribution system. Coordinate with the Physical Plant for all operations carried out on the network such as tapping of power or switching on or off of primary switches.

New construction works shall be consistent with the proposed new distribution system for the University. Accordingly, the power distribution network will be built up so that the University will migrate slowly towards purchasing its full power requirements from the Utility.

In order to achieve this goal the solution must be:

- Engineered to permit growth.
- Flexible for daily operation and switching back and forth between power sources.
- Reliable by maintaining power even if two faults occur.
- Upgradeable.
- Supports transition periods without power interruptions.
- Supports Future Service Level Agreements (SLA) with the authority.



The basic components of the system shall be the following:

- Subscribe with the public utility at 10 MVA (with conditions to increase subscription without changing incoming cables).
- Build a new substation building of 25m x 10m approximate size.
- Purchase 20 / 3.3 kV, 12.5 MVA transformers.
- Purchase new switchgear.
- Provide some new cables to transformer substations to form complete loops.

Refer to the power schematic diagram of the proposed new distribution system.

A. Mode of Operation and Slow Migration

First Five Years

Initially only one transformer would be purchased and three 20 kV switchboard cubicles.

EDL power will feed one side of the 3.3 kV bus. The power plant will feed the more essential (Hospital, College Hall).

When the utility peak rates apply (4:30 p.m. - 8:30 p.m. in Winter and 7:30 p.m. - 10:30 p.m. in the summer) all the power will be derived from the power plant.

In bad or extreme weather conditions, more generators would be on providing a safe spinning reserve to transfer the power to the power plant in case the utility fails.

Years Five to Ten

The other transformer would be purchased and two 20 kV switchboard cubicles. A second utility line from another source will be required to enhance reliability.

EDL power will feed all the loads. The power plant will be only stand by.

If overpriced utility rates still persist the plant may be operated to save cost on partial load. In bad or extreme weather conditions, generators would run idle providing a safe spinning reserve to transfer the power to the power plant in case the utility fails.

Years Ten on

With the substation plant fully developed and two utility sources a Service Level Agreement (SLA) may be concluded with the Utility to guarantee 99.99% power availability.

As transformers and distribution network age, replacement by 20 kV rated equipment may take place. The voltage of the University can easily be synchronized with the utility (20 kV), reducing losses, simplifying spare parts and enabling growth on the network.

EDL power will feed all the loads. The power plant will be only stand by and slowly retired.

If overpriced utility rates still persist the plant may be operated to save cost on partial load.

B. System Benefits

- The electrical power plant will slowly become a standby source.
- Noise and emissions of the power plant would slowly disappear.
- Measures to counteract utility blackouts and power rationing will be available.
- Power will not be purchased from the utility during peak hours where rates are grossly overpriced.
- The power distribution network would resemble a well thought of engineered solution.
- Manipulating, operating, monitoring and troubleshooting will be central and easy.
- The medium voltage used will become as the standard in the country.

C. Summary

A new power substation will be built to house new distribution transformers rated at 20/3.3kV and

accompanied with appropriate primary switchgear (20kV) and secondary switchgear (3.3kV). The system will be fed with power from EDL at 20kV and distributed across the campus at 3.3kV.

The governing policy shall be to install new infrastructure rated for 20kV and operable at 3.3kV. When the time allows power at 20kV shall be provided directly to the building substations and the building 3.3kV switchgear shall be abolished. The 20/3.3kV transformers and associated 3.3kV switchgear of the main campus substation shall be bypassed. The resultant network ratings and specifications shall become in-line with the prevailing trends adopted by the Utility and the local market.

For new construction works, the distribution system shall operate at 3.3kV but shall be rated for operation at 20kV. This policy shall apply to new MV loops laid directly in ground across the Campus and to transformer substations provided for new facilities and refurbished facilities.

2.2.2 General Provisions

The buildings 3.3(20)/0.4kV step-down transformer substations shall be located indoors. Moreover, spaces shall be allocated within the buildings to house electrical distribution equipment and cables in the form of dedicated rooms, closets, shafts and clearances above false ceiling to ensure adequate provisions for accessibility, service and maintenance. Electrical and communication rooms/closets shall be separate.

Provide adequate ventilation for equipment rooms based on expected equipment heat dissipation characteristics and recommended operating environmental conditions.

Final distribution to the loads shall occur at 380/220V, 3 phase, 4 wire, 50Hz. In renovation works or additions to existing buildings, the existing final distribution installations at 190/110V shall be abolished.

Allow for a spare capacity of 20% additional load capacity in the main incoming feeders for future growth in the facility.

Also allow in all panel boards (distribution panel

boards, final branch circuit panel boards and motor control centers) a minimum of 20% spare breakers.

All Panel boards shall be provided with wiring diagrams and typed directories indicating clearly circuit numbers and description of loads.

Enclosures of all equipment such as panel boards, motor control centers and individually mounted disconnect switches shall be suitable for the environment where they are installed such as wet locations, outdoors, or areas subject to accumulation of dust.

Provisions for multi-level Metering and Monitoring of electrical power shall be implemented locally at the buildings and at departments within the buildings. Consideration should be given to facilitate tracking of load consumption by HVAC and other loads such as lighting. Provide multi-function digital metering with feedback on peak power demand, energy consumption, power factor, voltage and current.

Separate conduits and wire way installations are to be used for medium voltage cables, low voltage feeders and sub-feeders, normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring. Cables of different voltages are not to be mixed within the same conduit or wire way.

Provide anti-slip, synthetic, insulating, rubber mat, minimum 5 mm thick and 900 mm wide, with heavy canvas lining on lower face along the full length in front of switchgear assemblies.

2.2.3 Medium Voltage Switchgear

Specifications of transformer substations shall be in accordance with paragraph 2.2.1 above. Substations shall include MV switchgear, MV transformers and associated auxiliary equipment. All installations shall be rated for 20kV but will be operated at 3.3kV.

Equipment shall comply the relevant IEC Standards including but not limited to:

1. Common clauses for HV switchgear and control gear standards: IEC 60694.
2. A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and

including 52 kV: IEC 60298.

3. HV a.c. circuit breakers: IEC 62271-100.
4. Insulation coordination: IEC 60071.
5. HV a.c. switch-fuse combinations: IEC 60420.
6. A.C. disconnectors (isolators) and earthing switches: IEC 60129.
7. HV switches: IEC60265.
8. Surge arrestors: IEC 60099.
9. Metering and protective current transformers (CTs): IEC 60144-1.
10. Metering and protective voltage transformers (VTs): IEC 60186.
11. Relays: IEC 60255.
12. Reading instruments: IEC 60051.
13. Watt-hour meters: IEC 60521.
14. Power transformers: IEC 60076, 60354, 60726.
15. Insulating oil: IEC 60296.
16. Sulfur hexa-fluoride: IEC 60376.
17. Fuses: IEC 60282-1.

The MV switchgear will comprise a ring main indoor unit of the metal-enclosed type, factory built and dispatched as a complete assembly. Components shall consist of two metal enclosed network ring main switch-disconnectors and outgoing fuse-switch combination(s), with cable terminal fittings behind dead-front panels, and front-mounted switchgear operation, control, indication and metering devices.

Busbars shall be air-insulated, high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fiberglass reinforced epoxy to approved standards.

Ground (Earth) bus shall be of copper of not less than minimum size required by the Standards, designed to withstand worst earth-fault current of power system without showing any signs of thermal or mechanical damage or degradation. Earth bus is to extend full length of switchgear.

Power cable terminations shall be fixed bolted type, complete with standard fittings and accessories for connection of incoming and outgoing cables. Cable compartment is to be designed to permit cables to enter enclosure and connect at respective terminals. Terminations are to include appropriate sealing ends, fittings and accessories for type of cable used, including stress cones or other stress relieving accessories, heat shrinkable sleeves, end boxes or end bushings and fittings of any kind necessary to support and protect specified cable ends.

Provide necessary indicators, measuring instruments, interlocks and earthing arrangements.

2.2.4 Medium Voltage Transformers

Power transformers shall be of the dry cast resin type, 3-phase, two winding, solventless cast epoxy resin, vacuum pressure impregnated windings, with minimum class F insulation on inner LV cores and class B on outer MV cores, rated for continuous operation under worst site ambient conditions at full load, and complying with IEC 60726. Temperature rise is not to exceed 70 deg. C over an average ambient of 40 deg. C for class B insulation and 90 deg. C over an average ambient of 40 deg. C for class F insulation. Insulation and encapsulation shall be humidity resistant, explosion and fire-resistant, self-extinguishing, tropicalized, giving non-toxic gases in the event of fire. Rubber sound isolation pads are to be provided between core and coil assemblies, and between base and housing. Cooling fans shall permit 30% increase in rated power.

2.2.5 Main Distribution Boards

Main distribution boards shall accommodate Service Entrance power requirements to the building. The main distribution boards shall be of the freestanding type, housing the copper bus bars and the incoming

and outgoing circuit breakers, surge suppressors, ground fault circuit interruption or monitoring, metering, etc.

Incoming breakers shall be of the withdrawable, air circuit breakers type, fully rated (100 %) with continuous duty at site conditions, rated for a symmetrical RMS service short circuit breaking capacity to meet available fault currents at specified voltage and frequency. Trip units shall be totally enclosed, solid state type and plugged into the front of circuit breakers. Outgoing breakers shall be fixed molded case type to NEMA AB 1, totally enclosed, fully rated (100%) and with a frame size and interrupting capacity to meet available fault currents.

The main boards shall be installed in a dedicated main low voltage "switchboard" room. Spare circuit breakers and space, to add in the future, power factor correction capacitors, shall be provided.

Provide Ground Fault Circuit Interruption or Monitoring in accordance with the NEC.

Comply with NEMA PB2 and NEMA PB2.1.

Enclosures shall be steel NEMA 250 Type 1 or NEMA 250 Type 3R as applicable to particular installation.

The main distribution boards distribute power to distribution panel boards and branch panels located on various floors.

2.2.6 Distribution and Branch Panels

Distribution panels and branch panels (for lighting and appliance branch circuit feed) shall be totally enclosed, made of sheet steel surface mounted in electrical rooms and closets and recessed otherwise, housing the copper bus bars and the incoming and outgoing circuit breakers, surge suppressors, ground fault circuit interruption or monitoring, metering, etc.

All breakers shall be of the molded case (MCCB) type to NEMA AB 1. The breakers shall be fully rated and selected in accordance with fault level available at the point of installation. Each panel shall have a neutral and ground bus. Spare breakers and spaces shall be

provided for future expansion. Branch breakers shall be loaded to 75 % of breaker capacity.

Comply with NEMA PB1 and NEMA PB1.1.

Enclosures shall be to NEMA PB1 Type 1 to meet environmental conditions at installed location. Enclosure types shall be considered per application such as NEMA 250 Type 3R for outdoors and NEMA 250 Type 4, for wet or damp indoor locations.

2.2.7 Motor Controllers and Motor Control Centers

All motors shall have controllers. Provide individually mounted motor controllers for all motors, which do not have an associated control assembly located within a motor Control center, switchboard, or panel board. Packaged equipment already specified with controllers, shall not have additional controllers.

- Controllers shall be to NEMA ICS 2:
 - Manual: NEMA ICS 2, general purpose, Class A, quick make, quick break, toggle action and overload element,
 - Magnetic: NEMA ICS 2, Class A, full voltage non-reversing, across the line, magnetic, with overload protection
 - Multi-speed: full voltage, non-reversing, across the line, magnetic, multi-speed
 - Reduced voltage: star-delta (closed transition with adjustable time delay), autotransformer (closed transition), part winding (closed transition with separate overload relays for starting and running sequences)
 - Other solid-state starters such as variable frequency drives (VFDs) suitable for controlled load.

Combination starters shall comprise the magnetic controller, switch disconnect (NEMA KS1 heavy duty) and short circuit protection in an approved sheet metal enclosure to suit the application.

Controller enclosures shall be NEMA 250, Type 1, unless otherwise indicated to meet environmental conditions at installed location, such as NEMA 250, Type 3R (outdoor locations) and NEMA 250, Type 4 (wet or damp indoor locations).

Motor control centers (MCCs) shall be totally enclosed, freestanding, modular, compartmented, located in the mechanical rooms. MCCs shall be constructed from 2mm thick sheet steel braced to sustain maximum short circuits.

MCC enclosures shall be NEMA 250 Type 1 or NEMA 250 Type 3R as applicable to particular installation to meet environmental conditions at installed location.

Wiring shall be class II type B to NEMA ICS 3. All controls shall be provided in the MCCs to enable a clean and simple interface with other systems such as the fire alarm system.

2.2.8 Disconnect Switches

Disconnect switches shall be NEMA KS 1, horsepower rated for the load they control, non-fusible, air-break single throw, safety type, double pole for single-phase loads or three poles for three phase.

Provide individually enclosed switches (safety disconnect switches) conforming to NEMA KS 1, Type HD (heavy duty) where a circuit serves a motor, a motor controller, or appliance unless one or more of the following pertains:

- Where the circuit protective device is within sight of and within 15 meters of the motor, motor controller, or appliance.
- For motors where the branch circuit protective device is pad lockable in the OFF position.
- For appliances that are cord and plug connected.
- Where the National Electrical Code does not require the switch.

2.2.9 Automatic Transfer Switches

The automatic transfer switch (ATS) shall consist of an inherently double-throw power transfer switch unit and a control module interconnected to provide complete automatic operation.

ATSs shall be of the contactor type, having double bypass feature enclosed in a sheet steel cubicle. In case of the failure of the transfer switch, the contactors may

be drawn out for maintenance. The bypass feature shall ensure the continuity of power flow manually to either the standby or normal power supply sources.

In addition to the contactors, the ATS shall include all controls necessary for automatic transfer of power supply from normal source to stand-by source, voltage sensing control relay and time delay relays to signal generator start and stop, auxiliary switches and indicating lights etc. as necessary for the required operation of the system.

The ATS shall be electrically operated and mechanically held. Breaker type transfer switches will not be acceptable.

Specify the number of poles, amperage, voltage, withstand and close-on ratings to suit application.

Comply with UL 1008, NFPA 70 and 110.

For applications related to the Medical Center, the ATSs shall comply with NFPA 99.

2.2.10 Wires and Cables

A. General Requirements

- In general, all feeders will be installed in conduits laid on cable trays, in trenches or in vertical shafts. Cables exposed above suspended ceiling are to be plenum rated.
- Life safety and critical feeders shall be of the fire rated type capable of sustaining flames for one hour.
- Cable penetrations through fire separation zones shall be capped off with fire stopping material.
- Cable sizes shall be given in metric units.
- Cables shall have copper conductors stranded for sections 4 mm² and above, based on IEC 228 Class 2. Signal and control cables are to have solid conductors. Flexible cords are to have finely stranded conductors. Conductors of single core cables 25 mm² and above are to be compacted. Multi-core cables 35 mm² and above shall be of the sectoral shape.

- Cables buried directly in the ground shall be armored, protected by concrete tiles and warning tapes. When crossing under roads, pipe banks or other services, directly buried cables are to be laid in heavy-duty PVC duct banks. In no case are cables to be directly buried in concrete, in masonry or in floor finish.
- Cables shall be color coded or otherwise identified in accordance with the Regulations as applicable to the voltage system. Building wiring insulation shall be as such:
 - Red, Blue, Black for the phases (1,2,3)
 - Grey for the neutral
 - Green/Yellow for the earth
 - Phase conductors for which outer jacket is not color-coded are to have engraved alphanumeric mark (L1, L2, L3) or color-coded heat-shrinkable sleeves.
- Low voltage main feeders and sub-feeders extending from the transformers to the automatic transfer switches, the main distribution boards and the distribution panels on the floors, shall be copper, XLPE insulated, and PVC sheathed single-core cables.
- Feeders from the distribution panels to final branch circuit panels shall be copper, XLPE insulated (for large cables) or PVC insulated and PVC sheathed single-core cables (for cables less than or equal to 16mm²).
- Control and signal cables, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade.
- Tag main and feeder cables in pull-boxes, wire ways and wiring gutters of panel boards or distribution cabinets. Tags are to identify cable or circuit number and conductor size. Where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit is to be tagged as a guide in making connections.

B. Outline Specifications

- Single core PVC insulated cables (building wires)(branch wiring): single conductor cables for wiring in conduit are to have annealed copper conductors, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC/E to IEC 227 (type 5 to BS 6746), suitable for wet locations and for conductor temperature of 85 deg. C, 450/750 V grade.
- Single core XLPE insulated feeder and sub-feeder cables (0.6/1 KV): circular stranded, annealed copper conductors, insulated with flame retardant, moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 deg. C. and PVC over-sheath. Armored cables are to have taped bedding, single wire aluminum armour and PVC over-sheath.
- Low smoke and fume (LSF) cables: 600/1000 V grade, copper conductor, insulated with extruded LSF material in compliance with BS 6724 for armored cables and BS 7211 for unarmored cables. Materials used in construction of LSF cables are to be nominally free from halogens (fluorine, chlorine and bromine). When material is tested in accordance with BS 6425, Part 1 and IEC Publication 754, Part 1, the acidic gas evolved during combustion is to be less than 0.5%. When tested in accordance with BS 2782, method 141D or ASTM method S2863, the oxygen index of bedding and sheathing materials is not to be less than 30. Completed cable is to meet the requirements for tests under fire conditions when tested in accordance with BS 4066, Part 1 and NMV 1.5 of BS 4066 Part 3. Cable sheath is to be extruded black LSF material.
- Flexible cable for connection to appliances, window fans, pendants etc. is to be 300/500 V grade to BS 6500, three or four core, with tinned finely stranded copper wires, EPR insulated, twisted and sheathed with chlorosulphonated polyethylene (CSP) compound and with strengthening cord.
- High Temperature Cable - Type MICC: 1000 V grade, annealed solid copper conductors, embedded in densely compacted mineral insulated, and contained in seamless annealed tubular copper sheath for continuous operation at 250 degree C, and for short duration at temperatures up to 1000 degree C, and waterproof. Cable is to be BICC type Pyrotenax or other equal and approved, supplied with standard fittings, terminations etc. by the manufacturer.
- High temperature cable - type FP 200: solid or stranded plain annealed copper conductors to BS 6360 (in sizes up to 4 mm²), extruded silicon rubber insulation to BS 6889 (0.6 mm radial thickness), PVC/PVC laminate and PVC composite sheath with tinned earth continuity conductor/drain wire. Cable is to be rated 300/500 V, capable of accepting voltage surges up to 5 kV, to operate continuously at 150 deg. C and for short durations at 200 deg. C. It is to be certified to have passed IEC 331 and IEC 332 flame resistance and fire retardant tests. Cable is to be Pirelli Cables type FP200 or other equal and approved.
- High temperature cable (125 deg. C) - type SA: single conductor, rated for maximum 600 V service, suitable for special applications. Silicone rubber insulated with outer covering of asbestos, glass or other suitable braid material.
- Multi-Core PVC Insulated Control Cables: 0.6/1 kV rating, solid 1.5 mm², 2.5 mm² or stranded 4 mm² plain circular copper conductors, with heat resistive PVC/E to IEC 227 (PVC type 5 to BS 6746), rated for 85 degree C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC over-sheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. Armored cable is to have extruded PVC bedding which may be an integral part of the filling, galvanized steel wire armoring, and over-sheath of PVC type ST2 to IEC 502, color black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.
- Control and signal cables, for use on data systems, are to be generally 300 V rating, polyethylene insulated (PE), color coded, tinned copper con-

ductors (0.6 mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

- Medium Voltage Cables shall be three-core (24kV maximum between phases), XLPE insulated, and is to comply with IEC 502, and have the following characteristics:
 - Conductor: copper, circular, stranded and compacted.
 - Conductor screen: extruded semi-conducting layer.
 - Insulation: extruded cross-linked polyethylene (XLPE), minimum 5.5 mm thick.
 - Insulation screen part: non-metallic directly applied extruded semi-conducting material, readily strippable.
 - Metallic part: layer of copper tape applied with 30% overlap.
 - Filling and bedding: polypropylene extruded over laid up cores to form compact circular bedding.
 - Armor: single layer of round galvanized steel wire.
 - Outer sheath: extruded PVC (color red) type ST2 to IEC 502.

2.2.11 Grounding

The grounding configuration shall comply with the NEC Article 250. Grounding equipment shall comply with UL 467. The ground source shall be provided at the transformer substation, consisting of multi-ground electrodes located in approved pits interconnected by a bare copper conductor cable directly buried in earth and arranged in a loop to provide two paths and bonded to the main metallic water pipe. Transformer neutral shall be connected to the main ground source. Ground bars shall be provided in electrical/communication rooms/closets and near motor control centers, interconnected in a radial configuration via wires sized to code. Protective ground conductors shall run in each conduit for grounding of

receptacles and lighting fixtures. All non-current carrying metallic objects shall be bonded to the ground.

Provide functional ground electrodes for grounding of sensitive electronic equipment such as computers. A dedicated grounding riser shall extend from the Signal and Communication systems grounding bar located in the building main communications equipment room to each service and central equipment location and wiring location for grounding of miscellaneous communications equipment.

Comply with NFPA 780 and UL 96 when interconnecting with the lightning protection system.

The ground electrode shall have a total combined resistance value, during any season of the year and before interconnection to other ground systems or grounding means to IEEE 142 and IEEE 80, not exceeding:

- 10 ohms for equipment rated 500 kVA and less,
- 5 ohms for equipment rated 500 to 1000 kVA,
- 3 ohms for equipment rated more than 1000 kVA,
- 5 ohms for substations and pad-mounted switching equipment,
- 10 ohms for manhole grounds.

2.2.12 Reliability and Quality of Power

Measures should be taken to reduce harmonic contents in the power system and improve the quality of power depending on the application and the magnitude of non-linear loads. Measures may include use of K factor rated transformers, over sizing the neutral and specifying an upper allowable limit on the Total Harmonic Distortion of fluorescent lamp ballasts and Variable Frequency Drives of motors.

Provide transient voltage surge suppressors (TVSS) for the protection of low-voltage power, control, and communication equipment as required for the particular application. Comply with IEEE C62.41, IEEE C62.45, IEEE C62.1, IEEE C62.11, NEMA LS 1, UL 1283, and UL 1449. TVSS shall be selected to meet requirements for the expected exposure Category.

Transient voltage surge suppressors include service entrance suppressors, panel board suppressors, auxiliary panel suppressors and plug-in surge suppressors.

Protectors for copper control, data, antenna and telephone conductors entering the building from the outside shall be as recommended by the manufacturer for the type of line being protected or for the expected exposure Category.

2.3 Lighting And Branch Wiring

2.3.1 Design Criteria

Lighting installations shall be carefully planned to be functional, easy to maintain and energy efficient. Lighting shall be provided shall be in accordance with the recommendations of the IESNA Handbook and ASHRAE 90.1.

Consideration should be given to daylight integration and control, glare reduction, illuminance (both horizontal and vertical), uniformity of light distribution over the task plane and color appearance. Lighting requirements should be assessed based on the visual tasks particular to a specific area. These tasks can be reading, writing, use of Visual Display Terminals (VDT's), audiovisual presentations, multipurpose activities, sports, etc.

Selected lighting fixtures will be available from multiple manufacturers. Specifying custom-made fixtures or a wide variety of fixtures should be avoided.

Fluorescent lighting will be generally used throughout and selected for specific room requirement. Incandescent fixtures shall be utilized in specialty areas and at the bare minimum level. Employ new developments in the fluorescent lamp industry and luminaries technology regarding energy efficiency such as T-5 tubes and electronic ballasts. However, areas dedicated to health care and housing diagnostic and monitoring equipment, shall be provided with T-8 tubes and magnetic ballasts to avoid interference problems.

For high ceiling sports halls, High Intensity Discharge (HID) and fluorescent light sources shall be utilized.

Lighting layout should be coordinated with the false ceiling layout and other fixtures and obstructions in the ceiling. Specify the highest efficiency luminaire for each specific area.

Provide low glare fixtures in computer laboratories and offices supplemented with task lighting.

2.3.2 Illumination of Means of Egress and Emergency Lighting

Illumination of means of egress shall be provided in exit stairs access corridors, in exit stairs and in exit discharge ground floors lobbies. Illumination shall be maintained and un-switched. Floors and walking surfaces shall be illuminated to values of at least 10 lux measured at the floor. Required illumination shall be arranged so that the failure of any single lighting unit does not result in an illumination level of less than 2 lux in any designated area.

Illumination of Means of Egress shall be fed from the Standby/Emergency Power Supply System of the building.

Additional emergency lighting shall be provided for all public areas (such as restrooms and lecture halls). Selected night-lights shall be maintained within the building to ensure easy circulation.

For certain critical areas (such as the transformer room, the main switchboard room, the generator room and the main communication room), lighting fixtures equipped with self-contained rechargeable battery packs for a minimum duration of 1 1/2 hours in accordance with NFPA 70 Article 700, shall be provided.

2.3.3 Marking of Means of Egress: Exit Signs

Approved signs in compliance with NFPA 101 shall mark exits and exit access; directional signs shall be placed in every location where the direction of travel is not apparent.

Exit signs shall be ceiling or wall mounted, single or double faced as required illuminated and provided with graphical legends. Exit signs shall be maintained.

In addition to being fed from the Standby/Emergency Power Supply System of the building, exit signs shall be provided with self-contained re-chargeable battery packs ensure continuity of lighting in the interval that extends between mains power supply and generator supply for a minimum duration of 11/2 hours.

Light Emitting Diode (LED) light exit signs shall be utilized. Colors, legend and dimensions of exit signs shall comply with NFPA 101 requirements.

2.3.4 Outdoor Lighting Installations

For outdoor lighting installations, refer to " DESIGN GUIDELINES FOR THE AUB LANDSCAPE" of the AUB master plan.

2.3.5 Lighting Control

Power consumption of lighting installations must be minimized by implementing lighting control measures during periods of no occupancy or during penetration of daylight through the windows and skylights.

Lighting of building interiors such as corridors, lobbies, storage rooms, utility rooms, restrooms, classrooms and lecture halls with infrequent or intermittent occupancy, shall be controlled using motion sensors (occupancy detectors).

For large halls, employ light zoning to maximize use of daylight. That way, switching of perimeter rows of light near the windows separately may be possible whenever daylight allows through photocells and dimmers. Zoning also allows switching off the lights in zones of inactivity.

Use photocells control of staircases provided with daylight.

In lecture theaters, turn light ON and OFF in rows through motion sensors. Lighting shall be dimmed and programmable to provide multilevel switching suitable for different scenes for different applications such as demonstrations and verbal lectures.

Lighting of outdoor areas shall be controlled by photocells.

2.3.6 Branch Wiring & Raceways

A. Outline Specifications

- In general, conductors for lighting and general purpose receptacle circuits shall be 4mm² minimum and protected by 20 Amps circuit breakers. A minimum size of 20cm in diameter shall be adopted for conduits. Provide dedicated full sized neutral for branch circuits.
- Fittings for conduits used in corrosive atmospheres are to be specially treated.
- Raceways and boxes shall be Listed and Labeled as defined in NFPA 70 Article 100, and marked for intended use.
- Metal conduit and tubing:
 - Rigid steel conduit (RMC): ANSI C80.1.
 - Plastic-coated steel conduit and fittings: NEMA RN 1.
 - Electrical metallic tubing (EMT) and Fittings: ANSI C80.3.
 - Flexible metal conduit (FMC): Zinc-coated steel.
 - Liquid tight flexible metal conduit (LFMC): Flexible steel conduit with PVC jacket.
 - Fittings: NEMA FB 1; compatible with conduit/tubing materials.
- Nonmetallic conduit and tubing:
 - Rigid nonmetallic conduit (RNC): NEMA TC 2, Schedule 80 PVC.
 - RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.
 - Liquid tight flexible nonmetallic conduit (LFNC): UL 1660.

B. Raceway Applications

- Rigid heavy gauge steel conduit (RMC) is to be used for:
 - All exposed installations comprising lighting, power, low current, communication and signal system wiring, including mechanical equipment rooms, electrical equipment rooms, service areas.

- Areas classified as hazardous explosive area. Flexible conduit is not acceptable.
- Areas exposed to the weather.
- Surface mounted main and sub-feeder installations.
- Fire alarm and security systems.
- Light gauge steel conduit (EMT) is to be used for:
 - Exposed installations over false ceilings.
 - Exposed wiring installations used in conjunction with exit and escape route lighting.
- Rigid heavy gauge PVC conduit is to be used for:
 - Lighting and power circuits, low current, communication and signal system wiring, where embedded in concrete, earth & under floor.
- Flexible conduit of same material as corresponding conduit system is to be used for connection to motors, vibrating and non-rigidly fixed equipment and to fixtures installed in false ceilings.
- Flexible steel conduit is to be used in movable partitions and from outlet boxes to fixture over false ceilings when used as a return plenum. Conduits are to be liquid tight in damp areas.
- Liquid-tight flexible steel galvanized conduit is to be used in one or more of the following conditions:
 - Exterior locations
 - Moist or humid atmospheres where condensate can be expected to accumulate.
 - Corrosive atmospheres subject to water spray or dripping oil, water or grease.
- All conduits shall be either embedded in concrete or run exposed above suspended ceilings in vertical and horizontal runs parallel to the building lines.

2.3.7 Wiring Devices and Miscellaneous Equipment

Outlet boxes, plates and other devices shall be generally galvanized steel, suitable for type of conduit or cable system and location of installation. Shapes and sizes of boxes are to be of compatible standards as selected

switches, receptacles, lighting fixtures and installation methods.

Receptacles shall be selected to comply with the area of installation. Receptacles shall conform to American Standard, with composition base, single or duplex outlet, single phase, two pole, three wire, 20 A, 250 V NEMA 6-20R, of a Grade suitable for application (heavy duty, general duty and hospital grade) for polarized plugs with U-shaped grounding slot, green terminal screw for grounding and flat parallel pins.

Ground-Fault Interrupter GFI receptacles shall be of the feed-thru type located in accordance with the NEC.

Receptacles finishes shall be as follows:

- a. Connected to Normal Power System: Brown
- b. Connected to Emergency Power System or UPS: Red
- c. TVSS Devices: Blue.
- d. Isolated-Ground Receptacles: Orange.

Provide industrial power receptacles in plant rooms. Power receptacles shall be polarized with aluminum alloy enclosure, interlocked switch and matching plug, to BS4343 and IEC 309:

- a. Single outlet, single phase, 3 wire, 16A or 32A, 6h, P+N+E, 250 V or
- b. Single outlet, 3 phase, 5 wire, 16A or 32A, 6h, 3P+N+E, 380 - 415 V.

Weatherproof receptacles shall be enclosed in surface mounted cast metal box and with cover comprising spring-retained gasket hinged flap. Enclosure is made up of a pre-designed box and cover for type of receptacle outlet specified.

Switches shall be quick-make, quick-break type, ivory, with silver alloy contacts in arc resisting molded base. Switches shall be single way, two-way or intermediate as required, rated 20A Specification Grade, 240 V A.C., toggle operated.

Colors of wiring devices shall be confirmed with the Facilities Planning and Design Unit.

Ceiling-Mounting Occupancy Sensors and Switch-Box-Mounting Occupancy Sensors shall be of the passive-infrared type that detects occupancy by a combination of heat and movement in zone of coverage. Sensor detects occupancy anywhere in an area of ~ 93 m² by detecting occurrence of 150-mm minimum movement of any portion of a human body that presents a minimum target of 232 cm² to the sensor. Unit turns lights on when room or covered area is occupied and off when unoccupied. Time delay for turning lights off shall be adjustable over a range from 1 to 15 minutes, minimum. A manual override switch will turn lights off manually regardless of elapsed time delay. It shall be possible to adjust the ambient light level above which sensor will not turn lights on when occupancy is sensed.

Wiring devices shall be tagged and labeled with voltage, circuit numbers and feeding panel references. Panels and equipment shall be labeled using lamacoids.

Locations of lighting switches, receptacles and other outlets shall be coordinated with the furniture layout such as benches and counters and shall comply with the requirements of ADA.

2.4 Communications And Security

2.4.1 General

Allocate adequate space within buildings for a communication room to cater to all communication systems operation, management and wiring terminations. This room will house equipment racks for services such as telephone, data network, security, BACnet interfaces and fire alarm.

Provide the communication room with UPS power supply, emergency power supply and adequate ventilation to avoid heat buildup and damage to sensitive electronic equipment.

Interfacing of communication systems is a common procedure. Define clearly the scope of work in implementing interface procedures including provision of wires, termination of wires and other necessary equipment.

Communication services shall be routed separately from the power services.

2.4.2 AUB Data Network (AUBnet)

Today around 8000 students, faculty and staff take network access for granted, and are actually encouraged to explore new uses for bandwidth-intensive applications such as videoconferencing and broadcasting.

Both students and faculty have come to recognize the Internet as a powerful research tool. Administrative staff has come to rely on network applications to do their jobs. In short, network utilization is growing, and with it, the need for bandwidth.

A. AUBnet Scalable Data Network

Between 1995 and 1998, AUB invested nearly one million dollars in network infrastructure. AUBnet was built using asynchronous Transfer Mode (ATM) to provide campus communications data network to every resident student, campus classroom, as well as all faculty, staff and administrator desktops. Since then AUBnet undertook many technology updates, keeping an up to date status.

Today, AUB counts over 4,800 Gigabit certified Category 5 data outlets providing campus wide connectivity. AUBnet backbone rely on over 600 strands of multi-mode fiber optic cable forming redundant fiber optic mesh, and ensuring the capability of high-speed connectivity to every building.

The enterprise networking solution selected by AUB provides a multi-switch meshed ATM OC-3 backbone with ATM OC-3 uplinks to 48 nodes. Seven 3Com Core Builder 7000 HD switches with 2.5-gigabit non-blocking ATM switch fabric and Four Core Builder 3500 fast Ethernet routers form the heart of the network and provide redundant ATM connectivity to all campus buildings and the Medical center. One hundred and forty 3Com SuperStack 3300/1100/1000 switches offer over 3350 switched/dedicated 10/100 BaseT Ethernet ports to connect faculty and administrative offices, labs and residences.

AUB uses 3Com's Transcend network management and SunNet Manager to create a management structure that enables easier configuration, better performance and reliable operation.

The ATM infrastructure also gave AUB the ability to establish Virtual Local Area Networks (VLANs) for a more flexible, secure and cost effective network management. VLANs were built to serve administration, student lab, residences and Internet functions.

B. AUBnet Gigabit Migration

AUBnet backbone will completely shift to a meshed non-blocking layer 3 gigabit by end of 2002. This advance connection will provide AUB Campus and Hospital with higher bandwidth and video/voice over IP QOS. College Hall shift was completed in November 2001, while the data centers (CNS computer rooms) Gigabit migration will be terminated by the end of February 2002.

C. AUBnet Wireless Data Network

CNS is currently in the process of installing several wireless network access points. These wireless connections cover the Jafet Library main study room, Engineering Library study room and the AUB main Cafeteria. Future wireless expansion will cover the Architecture student labs, and many other areas like Nicely A, West Hall, etc. The current installation can provide network/Internet access to approximately 240 concurrent users at the rate of 11 Mbps.

D. AUBnet Dial-Up Services

One Cisco Router, 3600 series, equipped with 48 analogue modem ports plus 12 dedicated PTT lines have been installed to provide off-campus dial-in ability, giving students/faculty access to Internet plus AUBnet services regardless of where they are located.

E. AUBnet Internet Connection

AUBnet Internet connection is via 4 redundant links via 4 ISPs providing:

- 1 X 128 Kbps link via DataSat
- 1 X 192 Kbps CIR (256 Kbps burst) via Data Management
- 1 X 256 Kbps via Terranet
- 1 X 256 Kbps uplink, 1.5 Mbps CIR (2 Mbps burst) via Opus Libani

AUBnet Internet connectivity and bandwidth are under continuous monitoring and upgrade.

2.4.3 Voice and Data Systems

A. Systems Description

The AUB Data Network (AUBnet) is configured on a fiber optic backbone emanating from the computer center at the Van Dyke Hall installed within the same duct banks of the Campus Telephone Network Copper Cables. All buildings are linked to this Network except for the Medical Center, which runs an independent Data Network.

The AUB Central Network Services (CNS) is in charge of operating and maintaining the Campus Data Network. All buildings shall be linked to this network. During design stages, coordinate closely with the AUB CNS Representative and ensure that University requirements are fully adhered to.

The AUB Telephone Network branches from 2 telephone exchanges linked together through a fiber backbone. The first is located in the Medical Center and the second is located in the Architecture Building.

For new construction works, duct banks shall be provided as required to link the buildings in question with the Telephone and Data Networks. Extension lines shall be derived from the existing exchange systems until the University decides to upgrade them to Voice Over IP (VoIP) and delete these exchanges.

Within each building (new or refurbished) a standard structured wiring system based upon a star topology to connect all manner of applications covering voice, data or multimedia applications, shall be installed. This strategy shall be adopted for the next coming 5 years until the AUB decides to migrate into Voice Over IP

(VoIP) Telephony. In that case both Voice and Data will share the same transmission medium.

The star topology is to be centered upon a Main Communications Room from which two separate wiring systems shall run and serve the various floors: one for the transmission of voice from Campus Telephone Network and the other for the transmission of data from Campus Data Network.

The server and all active components shall be specified and provided by the CNS. All passive components such as wiring, patch panels, racks and the like shall be fully coordinated with and approved by the CNS. Passive components shall be provided under the base building.

Data outlets (workstation outlets) shall be installed in all teaching spaces.

B. Outline Specifications

The Voice and Data system shall be subdivided into six components:

- Voice and data outlets: modular 8 pin suitable for RJ45 connectors,
- Horizontal cabling: horizontal wiring shall employ 100 ohm 4 pair unshielded twisted pair (UTP) in metallic conduits to TIA/EIA-568-A category 5e: two by four-pair (2 x 4) to each duplex RJ45 information outlet (work-area outlet).
- Horizontal cross connect (HC) for cable termination and cross connect cabling hardware located in floor communication closets: Distribution Cabinet of high professional quality, made of metal alloy, corrosion resistance, dust proof, wall mounted by screws, with tamper proof removable screw covers, cable holder rings, labeling plates, equipped with relevant connecting strips, and have efficient capacities to fully wire the complete incoming cable and outgoing ones.
- Backbone cabling: Backbone cabling shall be provided by two types of cables that extend to each telecommunication closet/room on individual floors: a multi-pair telephone cable and an optical fiber cable. The telephone backbone cables shall

be polyethylene insulated, tinned solid copper conductors, unshielded twisted into pairs, color-coded and gray PVC sheath. Minimum diameter of conductor is to be 0.6 mm. The fiber backbone shall be multimode 12-core, 62.5/125 mm and provided with fan-out tubing, with an attenuation of 3.75/1.5dB/km at 850/1300nm and a minimum bandwidth of 160/500 MHz km at 850/1300nm

- Main distribution frame (MDF) to connect incoming EPABX lines and all the copper backbone cables. MDF cabinets are to be double ended. In the MDF one side is to enable connecting the entire backbone cables (building side) with cross connects to the second side. The second side is to enable connections to the telephone exchange lines.
- Main data cross connect (MDC): for distribution of campus Data Network signals to the floor horizontal cross connect cabinets through the fiber backbone. The MDC houses modular fiber patch panels with multiple-numbered duplex cable connectors.

The MDF and MDC shall be high-quality metal alloy, free standing, floor mounted, space saving, on-site assembled, with modular sections, transparent covers for connection modules protection, cable ways, wire guide rings, easy break and test access, numbering plates, labeling strips for all terminal blocks, and frame grounding.

Punch-down insulation displacement connectors (IDC) shall be used on jacks, jack assemblies, patch panels, terminal blocks, and other components where the conductors of twisted-pair cables are terminated.

Provide the MDF, MDC and horizontal cross connect panels with the required type and adequate number of patch cords.

Operator's consoles shall be compact desktop type, equipped to provide all required services. Telephone sets shall be desk or wall mounted, push button operated with dual tone multi-frequency (DTMF) type. Sets shall be made of shock resistant molded plastic. Sets shall plug in the telephone outlets by snap on modular eight pin RJ45 plugs.

2.4.4 Fire Detection and Alarm System

A. System Description

All buildings whether new or renovated, shall be protected by a Fire Detection and Alarm System. The fire alarm system shall provide early detection, accurate location of zone and point of origin of fire and automatic control of the ventilation and air conditioning systems.

Fire alarm systems of all campus buildings shall be interconnected through loops to a Campus Main Fire Alarm Control Panel MFAC installed at a Fire Command Center (FCC). The FCC shall be dedicated for control and monitoring of fire alarm events throughout the campus. It shall be located at the College Hall under the auspices of the Environmental Health and Safety Center (EH&SC).

Each building fire alarm system shall form a sub-set of the campus fire alarm system. Every building Satellite Fire Alarm Panel (SFAC) would collect data from the building and send it to the MFAC in a loop configuration. The fire alarm loops shall be implemented using available spare cores of the Data Network fiber optic backbone already available in underground duct banks laid across the Campus

The University personnel in charge of fire protection services shall rely upon color graphics and CRT terminals (in parallel with the MFAC) to help identify the building in alarm, respond as early as possible to the fire and direct the fire brigade to the site of fire.

Fire alarm and notification shall comply with the fire services policy adopted by the University. Coordinate the project fire alarm "Cause and Effect Matrix" closely with the EH&SC.

B. Outline Specifications

The system shall be of the analogue addressable type with voice command feature (for special structures such as high rise buildings), microprocessor based, audibly and visually supervised, with detection and alert devices distributed where dictated by Code. The life safety system shall be composed of three subsystems for fire detection and alarm annunciation, emer-

gency voice/alarm, and two-way communication. The system shall be zoned and non-coded.

The following measures shall be taken:

- Interface with other systems such as security and door access systems, fire fighting, smoke control, stair pressurization, Building Automation and Control Network (BACnet), standby/emergency power supply, Audio Visual system, elevators, etc shall be required,
- Standby emergency power supply system shall be provided to ensure continuity of power supply to loads that are essential to life safety such as the fire alarm system, the FCC and Main Communication Room, the fire pump and mechanical equipment used for smoke control procedures and at least one elevator in every bank with power transferable to any other elevator in the bank.
- For special structures, a two-way telephone communication service is to be installed for fire fighters use. This system shall operate between the building central command and every elevator car, every elevator lobby and each floor level of exit stairs. Notification of occupants shall be achieved through a voice communication system.

The basic system components shall be the following:

- Main fire alarm annunciation and control panel MFAC, microprocessor based, addressable type, modular expandable, fully electronic, electrically supervised, divided into main compartments for control, annunciation and amplifiers. The system shall have batteries capable of monitoring the system for 24 hours and then sounding the alarm for 30 minutes.
- Color graphics CRT terminal
- Satellite Fire Alarm Panels SFACs for data acquisition, transmission and control. Wiring, between the speakers/horns, visual alert devices, emergency telephone, detectors, and control modules on one hand and the main control panel on the other hand, shall be via the satellite fire alarm panels

that have multiplexing features and amplifiers rated for the required audio load. Each building shall have an SFAC assigned to serve its various floors.

- Automatic and manual detectors consisting of smoke, heat, manual, duct smoke and sprinkler water flow. Detectors shall be located to code.
- Alarm notification devices consisting of audible alarms (bells, speakers and horns) and visual alarms (strobe lights). The voice alarm system shall be capable of broadcasting pre-recorded messages and have an interface with the fire fighters station at the main panel. The main fire alarm panel or MFAC/SFAC shall house the amplifiers sized in accordance with the number of speakers and wattage. Speakers shall have different tap settings and shall be adjusted on site for optimum performance and maximum coverage. Alert devices shall be designed to ensure a sound level of 15 dB above ambient noise in each area.
- Interface and control modules for releasing of fire rated doors separating fire zones.
- Fire fighters communication system consisting of telephone handsets located next to the exits on each floor and in every elevator car and elevator lobby for high-rise structures.
- Interface with the Building Management System for smoke management and control, sprinkler and fire pumps and HVAC control and with other systems such as security, standby/emergency power supply, elevators, etc.
- Remote repeater panels at strategic locations such as the main entrances.
- Data Network: each MFAC/SFAC panel is a node of a network with direct communications into the network but operates on a stand-alone basis. Although performing different functions, each MFAC/SFAC serves as a "peer-to-peer" (equal) partner in controlling network communications. Network information is sequentially transmitted from one node to another.

The fire alarm system shall provide visual and audible warning on main annunciator panel for supervisory signals such as:

- Failure or disconnection of power supply to main control panel
- Failure of fuse or protective device
- Removal of detector head on any initiating circuit
- Break or short circuit in wiring of any initiating or alarm circuit
- Valve tamper at fire pumps
- Fire pumps running
- Fire pumps power loss
- Fire pumps phase reversal
- Emergency generator on
- Emergency generator start failure
- Emergency generator low fuel
- Emergency generator low oil pressure

Even though an addressable fire alarm system shall be installed, buildings shall still be divided into zones to identify the location of a fire to help reduce confusion. The following criteria shall be followed in the zoning:

- A single zone shall not exceed 2000m².
- A zone shall not cover more than one story.
- Stairwells, elevator shafts and flue-like openings shall be treated as separate zones.
- The two hours fire separations dictated by the architectural requirements shall be used as separate zones.

2.4.5 Security Systems

Security aspects shall be assessed during project design development for each building individually depending on several factors such as building function, the facilities it houses; the circulation paths and staff overtime access rights.

The main objectives of security measures shall be to provide access control, circulation management and intrusion detection.

It shall be possible to maintain the required level of security without undermining the welcoming image and ease of access to the public.

In general, security shall be enforced based on a combination of:

- Managerial solutions relying on the human factor through security staffing, plans and procedures,
- Architectural solutions such as use of directive signage and structural partitioning of circulation areas,
- Technical (hardware) solutions including automated access control systems, intrusion detection and CCTV surveillance.

The technology of electronic security systems is constantly changing. All proposed systems shall be state-of-the-art and shall be specified following a thorough investigation of the technology supplied by prominent manufacturers in the market during design stage.

All systems shall accommodate the interface with other building systems such as the fire alarm and the BACnet. They shall be user-friendly and heavy-duty. Security cables are to be concealed, protected against physical damage and supervised for breaks.

Access control devices and alarm monitoring shall be carefully coordinated with the door locking hardware.

Security call boxes (Emergency Telephones) shall be specified and located as directed by the Facilities Planning and Design Unit/Physical Plant.

2.4.6 Audio Visual Systems

The requirements of audio visual aids for lecture rooms may range from ordinary overhead projectors in small lecture rooms to sophisticated integrated audio visual systems consisting of sound reinforcement, projection of video and data, motorized screens and remote control and interface with the lighting and HVAC systems in large lecture theatres. State-of-the-

art audiovisual systems shall guarantee an effective teaching/learning environment in line with today's multimedia age.

The Audio Visual system shall be coordinated with the designers of other systems including the architect, the lighting designer, and the HVAC designer and acoustics specialist for optimum results in performance, aesthetics and energy conservation.

All audiovisual equipment shall be rack mounted within the lectern or within a dedicated cupboard near the lectern. Power supply shall be distributed through a dedicated panel board located at the lectern. Connection points to the University Data Network shall be provided to accommodate direct links to the Audio Visual system computer and to an external computer at the lectern. A telephone is also required for outgoing calls as well as a gooseneck light and a gooseneck microphone.

Lighting of large lecture halls shall be dimmed and programmable to provide different scenes for different applications such as projection and lectures. Occupancy sensors as mentioned earlier in this document should override lighting control to cut down on the consumption of power. For the same purpose, it shall be possible for occupancy sensors to control the lecture hall HVAC system operation by providing the required interface between the audiovisual system and the BACnet.

The sound system shall produce high quality sound including speech reinforcement and audio/video reinforcement of multimedia and external sources, throughout the lecture hall and shall permit recording of lectures. The system shall consist of:

- Microphones: including lectern microphone and radio lapel microphone
- Provisions for external audio inputs and recording on external equipment
- Audio switcher: of various line level audio inputs used in conjunction with the video switcher. Switcher shall perform signal processing and pre-amplification of the signals before being input to the audio mixer

- Mixer: A minimum of six inputs, two outputs mixer. Inputs shall be received from the lectern microphone, the radio microphone, external microphone input, external audio line level input and audio switcher. Outputs shall be passed to the sound reinforcement system and to the recording system

- Sound processing equipment and amplifiers

- CD player

- Speakers: high performance, with frequency response suited for music and speech reproduction over all seating areas. Speakers shall be ceiling mounted. An additional pair of wall mounted speakers shall be required on the front wall of the lecture hall

The video system shall display video images and data information from the data network. The video/data projection and preview system shall consist of:

- Video/data projector: high quality projector appropriately mounted with respect to the projection screen and linked to the video switcher. Due to rapid changes and development in this field of technology, projectors shall be latest state-of-the-art regarding type, resolution, brightness, and image enhancement features
- Video switcher: shall accept inputs from an external computer, an internal computer, the VCR and two external video inputs
- Preview switcher and preview monitor: to select and preview any video or data input
- Video Cassette Recorder VCR and DVD player
- External inputs: from an external computer and external video sources
- Computer to be linked to the switcher and University Data Network
- Interface facilities of an external computer with the Video/Data projector

Provide also:

- Overhead projectors
- Motorized screens controlled from the Audio Visual control system and sized to comply with projection systems.

The control system shall consist of a software based control panel located at the lectern. The control system permits remote control through a portable controller and through wall entry plates. The system shall control the hall lighting, the video and the audio switchers, the motorized screens, or other blinds and shutters (as needed to blackout the daylight) from any location within the hall. It shall be upgradeable, easy to operate and maintain.

2.5 Other Electrical Systems

2.5.1 Standby/Emergency Power Supply

- For new buildings constructed during the coming 5 years, and due to the severe failures and rationing experienced with the Utility Power, standby/emergency power supply shall be provided by a standby power plant incorporated into the building capable of catering to the full building load. The plant shall have the facility of shedding low priority loads. The standby plant shall consist of one or more diesel generator sets operating in parallel via a synchronizing board to provide a reliable alternate source to all loads of varying priorities. Emergency loads specified by the Life Safety System and other critical loads shall have priority 1. Power shall be available to Priority 1 loads in 10 seconds.
- After 5 years, the 100% coverage of power through independent power plants shall be assessed. If the Utility Power becomes reliable, the requirements for Emergency Power shall become limited only to the Priority 1 loads mentioned above. The standby plants will diminish in size.
- Generators: The diesel generating sets shall be complete with associated auxiliaries, critical type silencer / exhaust system, start up system, cooling

system, bulk and daily fuel storage and power transfer systems. The generators shall be rated for prime power operation as defined by ISO 8528-1. The generators shall be mounted on concrete pads and shall have spring type vibration isolators.

- Generator rooms shall be sized taking into consideration arrangements for sound reduction, ventilation and accessibility. Calculate required noise level reduction at the geometric distance to nearest occupied space. Coordinate doors and insulating material with the Architect. Noise reduction is to be achieved by silencers, sound attenuators at air inlet and air outlet openings and sound absorbing wall lining. Achieve an overall Noise Rating of NR 70 (or 75 dBA) at 1 m outside the room in any direction.
- The Synchronizing Board shall ensure a smooth parallel operation of the generators. It shall be divided into two main sections, the parallel control and totalizing compartment and the electrically operated circuit breakers compartment.
- The generators shall operate as follows:
 - On receipt of a start signal indicating the loss of power, the generator sets shall automatically and independently start, accelerate to rated frequency and build up to rated voltage. The first unit to reach the preset levels closes to the bus while the other units shall be disabled from doing so. The first priority automatic transfer switch then connects its load to the standby power supply source. The priority controls prevent the overloading of the system bus by inhibiting the operation of the lower priority transfer switches until additional gensets are closed to the bus.
 - The control of the remaining gensets is switched to the synchronizer in each paralleling control. Each genset is then synchronized with the system bus and closed at the proper time. As each genset closes to the bus, it assumes its proportional share of the total load.
 - If a generator fails to start, or the bus overloads or a generator fails the corresponding breaker shall open (or remain open), the alarm shall sound and the lowest priority buses shall be shed.

- The microprocessor of the system shall continually monitor the total load on the bus, and should the system be able to carry the entire load safely with fewer generators, the controller will shut off some of the units.
- Upon restoration of normal power, all the generator breakers shall open and the gensets shall run unloaded for a cool down period and then shut off and be ready for automatic operation.

2.5.2 Uninterruptible Power Supply

For critical loads that do not tolerate interruptions, provide UPS units.

The UPS units shall be static type, complete with rectifier/battery charger and inverter sections, heavy duty sealed lead acid batteries installed in a panel and fitted with a bypass facility to ensure continuity of power to the critical loads in case of maintenance.

Redundancy and battery capacity shall be determined based on the type of supported load.

2.5.3 Lightning Protection System

Buildings shall be provided with a Lightning Protection system consisting of a Faraday cage connected to an independent ground through down conductors. The lightning ground electrodes shall be bonded to the main ground of the building. Coordinate the routing of down conductors with the building external skin and architectural features.

2.6 Medical Campus Special Systems

2.6.1 AUBMC Electrical Distribution System

Electrical Services form an integral part of healthcare facilities in providing a reliable service to patients. With time, healthcare procedures have become more sophisticated and more dependent on electrical apparatus. Consequently, the quality and continuity of power service, being directly related to the life-support and well being of patients, are far more essential in these institutions than in any other application.

To decrease the risk of power failures, NFPA 99, NFPA 70 and the IEEE Standard 602 mandate that

Electrical Distribution Systems in hospitals be divided into two systems: The Essential Electrical System and the Non-Essential Electrical System.

1. Essential Electrical System: The essential electrical system shall be comprised of two separate systems capable of supplying a limited amount of lighting and power service, which is considered essential for life safety and effective hospital operation during the time the normal electrical service is interrupted. These two systems shall be:

(i) The emergency system: The emergency system shall be limited to circuits essential to life safety and critical patient care. These are designated:

(a) The life safety branch: covering the following loads:

1. Illumination of means of egress and exit signs,
2. Alarm and alerting systems, such as fire alarm
3. Hospital communication systems,
4. Task illumination, battery charger for emergency battery-powered lighting and selected receptacles at the generator set location,
5. Lift cab lighting, control and communication,
6. Automatically operated doors used for building egress.

(b) The critical branch: This branch supplies these loads:

1. Task illumination,
2. Fixed equipment,
3. Selected receptacles,
4. Selected power circuits,

Where they serve the following areas and functions related to patient care: critical care areas, areas provided with isolated power systems, specific patient care areas, nurse call systems, blood bank, telephone equipment rooms and closets,

(ii) The equipment system: The equipment system shall supply major electrical equipment necessary for patient care and basic hospital operation such as:

- (a) Generator accessories essential for generator operation,
- (b) Compressed air systems serving medical and surgical functions,
- (c) Smoke control and stair pressurization systems,
- (d) Heating, Ventilating and Air-conditioning systems for specific areas such as the operating rooms,
- (e) Selected lift(s) to provide service to patient, surgical, obstetrical, and exit floors during interruption of normal power,
- (f) Fire pumps,
- (g) Fire fighting pressure maintenance (jockey) pumps.

2. *Non-essential electrical system:* covering all other loads.

Essential Electrical Systems shall have a minimum of two independent sources of power: a Normal Source and one or more Alternate Sources for use when the normal source is interrupted.

For new health care facilities comply with the above requirements. For any particular occupancy: clinics, ambulatory care centers, limited care facilities, etc, Essential Electrical Systems shall be either Type 1, 2 or 3 as defined and required by NFPA 99.

The alternate power source shall be provided by local standby /emergency power plants consisting of diesel generating sets.

2.6.2 AUBMC Electrical Distribution System

The electrical distribution system of the AUBMC exceeds the requirements of the reference Standards.

At the AUBMC, there are two alternate Power Supply sources for the:

1. City Network.
2. Main Campus Power.

Main Campus Power, in its turn, may be derived either from the City Network or from the on-site Campus Generated Power.

In terms of NFPA 99 and NFPA 70 and IEEE 602 Standard requirements, the Electrical Power System of the AUBMC has the following characteristics:

The Normal Power Supply Source is derived from the Utility through two different main feeders: 1- directly terminating at the AUBMC and 2- derived from Campus Power Plant. This adds up to the reliability of the system in case of failure in either branch of the Utility Network installations.

The Alternate Power Supply Source is derived from Campus Generated Power and caters to 100% of the load with a possibility of shedding the lower priority loads (non-essential loads).

Add to this, an on-site diesel generator provides for the Hospital's Essential Loads within 10 seconds in case of power failure from the above sources. Uninterruptible Power Supply Systems are used for sensitive medical equipment.

Main incoming Medium Voltage power supply feeders are terminated in the Main Intake Room. This room houses four compact packaged-type Load Centers through which the Medical Center is provided with power supply round the clock.

Regarding expected load growth, the four load centers are believed to have enough spare capacity to support all foreseen modifications including renovation of wards and the introduction of additional new equipment. This is because the modifications that are being implemented or are planned for the Hospital do not impose a change in the function of the renovated area. Add to this that the newly purchased equipment, will most often, be replacing an existing old one.

Coordinate with AUBMC Authorities for the derivation of power supply from any of these Load Centers. For all loads, identify the feeding branch in accordance with the code requirements listed above.

On the other hand, renovation projects within the Hospital shall take into consideration that the existing manual load shedding procedure should give way eventually to a remote automatic load shedding system. Coordinate with the Facilities Planning and Design Unit/Physical Plant to define the requirements at project inception.

2.6.3 General Interior Lighting Installations

The Hospital is generally lit with fluorescent T12 bulbs at 220 Volts from floor branch circuit panel boards designated as LP's or ELPs.

Lighting control of public areas is achieved manually. Guards and/or other staff will normally ensure that lighting levels of public areas are either maximized (during high activity periods) or minimized (during low activity periods) - generally between day and night - respectively.

The present lighting installations employ obsolete fluorescent lamps and lighting fixtures, which are energy inefficient compared to the new developments in the fluorescent lamp industry and luminaries technology.

Every renovation project within the Hospital shall take into consideration the above conditions and shall comply with the general guidelines stated above in this document for Lighting Installations and Lighting Control. Lighting installations should undergo a renovation process as per modern technologies in lighting fixtures, lamps and control and help reduce the consumption of energy.

2.6.4 The Isolated Power System

The isolated power system is a power supply that is capable of limiting ground fault current without power interruption. It shall be installed in specific patient care areas where power interruption under fault cannot be tolerated such as the operating rooms or the ICU ward. Isolated power shall be distributed through isolation distribution panels (IDPs).

Isolation Distribution Panels: IDPs shall house a dual voltage isolation transformer with a 220V primary and dual output (220V & 110 V) secondary, a line isolation monitor (LIM), a set of double-pole circuit breakers, ground bus, grounding jacks, and receptacle outlets. LIMs shall indicate earth leakage and fault currents.

2.6.5 CCTV And Patient Monitoring System

The patient monitoring system allows several patient parameters to be monitored by nursing staff at a central station. The system consists of interconnecting of

patient instrumentation to a central location. The type of devices and wiring depend on systems used and should comply with equipment supplier recommendations.

This system is usually implemented in critical care areas such as the ICU, the CCU and operating and delivery suites as an additional means of patient care. Patient monitoring may also be accompanied with CCTV for remote visual observation of patients.

2.6.6 CCTV For Educational And Consultation Purposes

The AUH being an educational facility, CCTV plays an important educational tool. In its simplest applications, CCTV allows live transmission of a surgical operation to a classroom or auditorium medical staff education. Other important application fields for CCTV are the audio-visual consultation between the frozen section (pathology) laboratory and the operating room, and within a radiology department. Comply with 47 CFR 15, 17, and 76.

CCTV Equipment shall comprise:

- Cameras: Silicon target, color, CCD type with 1/3 inch color pickup tube
- Motorized pan-and-tilt units arranged to provide remote-controlled aiming of cameras with smooth and silent operation and equipped with matching mounting brackets.
- Mounting brackets for fixed cameras.
- Protective housings for cameras.
- Monitors: Color, metal cabinet units designed for continuous operation screen size as appropriate for application
- Videotape recorder: industrial time-lapse type designed for continuous operation.
- Manual switch bank.
- Sequential switcher: automatically sequence outputs of multiple cameras to single monitor and videotape recorder.
- Pan-tilt-zoom controls.

- CCTV master control station: heavy-duty, free-standing, modular metal furniture units arranged to house standard mounting electronic equipment.
- Cabling shall be coaxial, 75 ohms nominal impedance.

Requirements for CCTV installations shall be assessed on a project basis.

2.6.7 Intercommunication System

The Intercom System is a two way loud-speaking communication means. In hospitals, it is often provided within particular wards where fast and simple internal communication among staff is essential to the functionality of the ward as a whole such as a surgery suite.

System is to provide two-way direct-connected, manually switched voice communication between master station and any or all slave stations simultaneously. The master station is to be capable of originating a call to one or more stations or to all slave stations by depressing appropriate station selector switch, which automatically sends call tone to desired station(s). Incoming calls from slave stations are to be announced with flashing LED and audible tone. Voice volume control is to be provided from the master station. Slave stations shall be equipped with speaker-microphone units and momentary call push button and tone generation for annunciation of calls from the master station. Comply with UL 50.

Requirements for intercommunication system shall be determined on a project basis.

2.6.8 Voice Paging System

Voice paging is a system that helps reach out for doctors and other key personnel quickly who may be somewhere within the facility but away from their offices. This system employs a network of speakers distributed around the public areas in the facility to transmit general announcements to the staff and/or visitors, paging messages and background music.

Voice paging shall be implemented through the fire alarm audio paging system presently being installed

throughout the Hospital. The new network of speakers shall serve the dual function of transmitting fire alarm announcements as well as audio paging messages and background music.

For renovation works at the AUBMC, comply with existing practices. Materials and equipment shall be similar to existing installations. Voice paging installations shall be connected to the existing hospital system.

2.6.9 MATV System

The MATV system is a system that distributes TV signals throughout a building for entertainment purposes. TV signals received at the antenna are processed by the head-end equipment (made up of amplifiers and signal processing equipment) and distributed throughout the building through the TV cable plant.

The Hospital is in the process of going out for bid to refurbish the existing installations, adding more services such as satellite TV. In future renovation works or additions, TV installations shall be provided to the wards through this system as required.

2.6.10 Nurse Call System

The nurse call system provides primarily for patient-nurse communication in addition to several other communication requirements within a nursing unit and between different nursing units.

For every ward being renovated the existing - original - nurse call system shall be replaced with a "Responder IV". Provide this system also for new projects where needed.

This system is an advanced digital model with integrated management software. It is a comprehensive microprocessor based, audio-visual nurse call system. Each department that requires the system shall have a master nurse call station. All master stations shall have the facility to be linked together through a network to integrate the system to provide advanced features.

Served by the master station are patient bed stations, toilet emergency stations, staff stations, duty stations, code blue buttons, dome lights and zone lights.

Different calls shall register different priority levels on the master station as follows:

| Call Type | Priority Level |
|------------------|----------------|
| Code blue | 1 |
| Staff emergency | 2 |
| Toilet emergency | 3 |
| Patient priority | 4 |
| Patient normal | 5 |

2.6.11 Code Blue System

In case of high medical emergency incidents such as a cardiac arrest, Code Blue alarms are relied upon to alert the persons in charge of delivering the crash cart and to notify the resuscitation team to rush to the area of incidence. Code Blue alarm stations are required in critical care areas such as the ICU, the CCU, surgery suite, labor and delivery rooms. Code Blue systems are generally integrated into the nurse call system, so that code blue alarms are annunciated at the respective Nurses Station as well as a central control location.

The AUBMC implements a Code Blue System. The Nurse Call systems that shall be provided at the AUBMC (Responder IV) incorporate Code Blue Call stations (push buttons). There is a designated Code Blue (STAT) Team at AUBMC, which is called upon through the radio pagers as well as a dedicated telephone number. Comply with the requirements of the AUBMC Policies and Procedures for STAT handling.

2.6.12 Wiring Methods

- Open cable wiring methods are being employed for routing of miscellaneous communication systems above false ceiling of circulation areas, i.e., insulated cables were being installed without the use of an enclosing raceway. In renovation projects within the Hospital, a cable tray shall be used to support and protect the cables. This cable tray will have to circulate all corridors above false ceiling and terminate within the floor communication closets. It should be wide enough to accommodate all existing communication cables and additional

future communication services. Cables will be neatly laid out independently from other services in the corridors for better protection, tidiness of work and ease of maintenance.

- Since the general trends in today's technology are producing equipment that operate at the preferable voltage of 220V rather than 110V, the 110V installations should give way eventually to 220V installations in accordance with a well-studied plan. In every renovation project within the Hospital, coordinate with the Facilities Planning and Design Unit/Physical Plant to define the requirements of 110V and 220V installations at project inception stage.

2.7 Electrical Site Utility Works

2.7.1 Outline Specifications

- Polyvinyl Chloride (PVC) Ducts for outdoor power and lighting cable installations are to be non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm², impact strength 5 kg/cm², supplied in standard 6 m lengths, with one end of each length tapered. Ducts shall have a minimum wall thickness of 3.2 mm for 100 mm ducts and 4.7 mm for 150 mm ducts.
- Duct Supports: pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.
- Covers for trenches in electrical rooms and the like are to be flanged chequered steel plates with angle or channel-section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats gray enamel.
- Covers for manholes and handholes: chequered cast iron or cast steel, recessed type, and of suitable duty for the particular application.
- Brackets, supports, rails and tracks for supporting electrical installations are to be galvanized steel,

fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

- Equipment foundations and bases: reinforced concrete. Dimensions, levels and surface finishes are to be suitable for equipment installed.
- Concrete envelope for duct banks for power distribution systems and outdoor lighting cable installations crossing water and sewage mains, under roadways is to be reinforced concrete Class B using Portland cement. Reinforcement is to consist of 12 mm diameter longitudinal bars at approximately 300 mm centers along bottom and sides of duct bank with 10 mm diameter U-shaped transversal bars at 400 mm centers. Length of concrete envelope is to extend at least 300 mm beyond each side of crossing etc.
- Cable manholes and handholes: reinforced concrete Class B using Portland cement, with approved waterproof membrane on external surfaces, and with cable supports where necessary, pull-eyes, and drain pit and drain pipe as required. Dimensions and reinforcement are to be in accordance with approved standard details or approved shop and construction drawings.

2.7.2 Workmanship

- Cable trenches: width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard spots from trench bottom and trim level.
- Directly buried PVC cable ducts
 - Lay and join ducts to required line and level on sand bed, cover with sand and backfill trench to ground level with excavated soil, free from stones and other debris, well compacted in layers not exceeding 300 mm thick
 - Lay approved concrete tiles to fully cover cable duct, extending minimum 50 mm beyond sides of duct and placed 300 mm below ground level.
 - Provide warning tape or galvanized steel mesh along duct runs at a depth 200 mm below ground level.

• Underground cable duct assemblies

- Form duct assembly to required line and level, using duct supports spaced to prevent sagging of ducts and breaking of couplings and watertight seals, and secured with cords (not tie wires) where necessary.
- Provide 1% slope to duct banks for draining to exterior manhole, handhole or other location as instructed.
- Join ducts using waterproof cement, to manufacturer's recommendations, to give waterproof and sand proof joint with at least 80 mm overlap.
- Provide 3 mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1 m beyond duct banks at both ends and securely fixed to wooden bungs sealing the duct.
- Ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.
- Conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapor.
- Sleeves or ducts shall be provided in equipment foundations.
- Directly buried ducts and underground duct assemblies are to be inspected before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90% of inside diameter of duct and 500 mm long, is to be pulled through entire run of duct and is to pass through without getting stuck. Ducts, which do not allow mandrel to be pulled through, are to be repaired or replaced. Clean ducts with stiff bristle brush pulled through each duct prior to pulling in cables.

2.8 Renovation Rules

2.8.1 General Considerations

To cope with the phasing nature of the AUB Master plan projects and to maintain the University operational during construction, the rules stated herein shall be strictly applied.

Contractor shall be instructed to visit the site to thoroughly examine and familiarize with the existing systems and installations and every other condition that may affect the work. No claims for extras shall be allowed for work or materials necessary for proper execution and completion of the contract or for the Bidder's failure, error or negligence in this regard.

All places are considered critical. The Contractor shall coordinate his work to produce the minimum disturbance and he may be asked by the University Representative to stop at times, dirty and noisy works.

Areas outside the project site can only serve as passage to transport material to and from the site. They should not serve for any reason as a storage place for supplied material or debris. All supplied materials should be transported directly from the truck to the site and all debris should be collected in bags and transported directly from the site to the truck.

2.8.2 Existing Installations

Work associated with existing installations shall be carried out as follows:

- All modifications and additions to the existing electrical distribution system as well as communication, security and miscellaneous systems shall be carried out in such a way that the interruptions to normal operations are kept to an absolute minimum, if at all. All such work shall be scheduled to the satisfaction of the Engineer and to the approval of the Owner, whose convenience shall be of the foremost importance.
- Where existing electrical equipment is to be relocated, the electrical subcontractor shall be responsible for disconnecting this equipment, removing and reinstalling in the new locations and

reconnecting. Hook up to the existing utility terminals shall be performed by the Physical Plant personnel or under their direct supervision.

- All existing electrical installations, in areas to be renovated, shall be removed and shall be replaced by new installations unless otherwise noted.
- Installations at locations from which existing equipment has been removed, shall be rendered safe by withdrawing the existing wiring and removing conduits. Where conduits are cast in concrete or are inaccessible they shall be sealed and left in place.
- All existing materials that are removed shall be placed in the Owner's stores to the directions of the Owner. Should the Owner not wish to take over these materials, Contractor shall remove them from the site.
- Circuits that may be disrupted by the removal of existing equipment, or as a result of renovations, shall be restored.
- Not all existing equipment and devices may be shown on the University As-built drawings. The Bidder shall obtain clarification from the Owner on unidentified equipment prior to submittal of his bid. The Contractor shall ultimately be responsible for restoring power to all equipment or devices in project areas that must be maintained operational and in full coordination with the Facilities Planning and Design Unit/Physical Plant.
- All existing power and communication cables supplying areas beyond the area being renovated, but passing through said space, must be maintained functional throughout entire construction period. No interruptions shall be allowed. Contractor and Facilities Planning and Design Unit/Physical Plant shall be responsible for identifying services that must be maintained.
- Contractor shall repair any damage to fixed or movable items caused by him during his work at his own expense.

CONVEYING SYSTEMS: ELEVATORS

3.1 Design Criteria

Elevators shall be provided in buildings to accommodate for the transport of persons, specifically the disabled and for the delivery of goods and disposal of garbage.

Designer shall carry out traffic analysis for the project under study and submit for approval. Traffic calculations shall show all parameters considered in the analysis such as estimated building population, traffic patterns, entrance and departure levels and the design criteria adopted such as the optimum interval and handling capacity for the particular application.

Elevators shall conform to the Fire Fighter's Service requirements. Tie-in to the fire alarm system shall be provided to park all elevators on the main entrance level upon receipt of a fire signal. An alternate park floor shall be provided in case the signal originated from the entrance level. Fire detectors shall be placed in hoist-ways and the machine rooms to shut off power and park the elevators respectively in accordance with NFPA 72.

Lighting and socket outlets shall be provided in the pits and in the elevator machine rooms. Disconnecting means, control signals and telephone connections shall also be provided.

Elevators shall be of the electric traction variable voltage variable frequency (VVVF) type. For particular

applications such as light-duty low-rise buildings, hydraulic type elevators may be permissible, however preference should be given to electric traction elevators.

The elevator banks operation shall be group automatic. Door operation shall be electronic with up-to-date safety features. Provisions shall be made for future installation of an access control system.

Passenger elevators shall be accessible to the handicapped and shall be fitted with Braille operating panels. The interior finishes shall be suitable for the corresponding application and shall be coordinated with the interior requirements.

Cars shall be provided with emergency lighting and partial natural ventilation. Elevators shall be provided with a battery emergency operating system that will operate in the event of power failure to supply power to the:

- The car lighting
- The emergency alarm system and to
- An emergency lowering device that allows car to descend to the next immediate floor and unlock the doors.

The batteries shall be re-chargeable type complete with an automatic re-charging system.

3.2 Regulations And Standards

- Elevator dimensions shall be selected according to the International Standard ISO 4190-1, "Lift Installation- Part 1: Lifts of classes I, II and III". This Standard identifies the following classes of elevators:
 - Class I: Elevators designed for the transport of persons.
 - Class II: Elevators designed mainly for the transport of persons but in which goods may be carried. They differ from class I and III elevators essentially by the inner fittings of the car.
 - Class III: Elevators designed for the transport of beds.
 - Class IV: Elevators designed mainly for the transport of goods, which are generally accompanied by persons
- Elevators safety features shall be to the American Society of Mechanical Engineers ASME A17.1, "Safety Code for Elevators and Escalators" and the ADA "Americans With Disabilities Act ".

MECHANICAL WORKS

4.1 Regulations And Standards

All HVAC, Plumbing and Fire Protection systems designs and installations shall comply with the requirements of the latest editions of the following codes, regulations, and references:

- Uniform Building Code
- National Plumbing Code
- National Fire Protection Association (NFPA Standards)
 - Design all medical gas system in accordance with the requirements of NFPA standard 99, and C11 (HTM 2022).
 - Alarm systems should be provided as per NFPA 99.
 - Design LPG in accordance with the Physical Plant requirements, NFPA Standard 58,59.
 - Design incinerators in accordance with the requirements of NFPA 82.
 - Refer to NFPA 10 for fire extinguishing systems.
 - Refer to NFPA Standard 11 for foam fire protection system.
 - Refer to NFPA 13 and 14 for sprinklers system and fire standpipe systems respectively.
 - Refer to NFPA Standard 17 for dry chemical fire protection system.
 - Refer to NFPA 17A for wet chemical.
 - Refer to NFPA Standard 20 for data on fire pumps.
 - Refer to NFPA 31 Standard for the Installation of Oil-Burning Equipment.
 - Refer to NFPA 70 Standard: National Electrical Code 1999 Edition.
 - Smoke management should be designed and installed according to the requirements of NFPA 92A, 92B, 204, and 211.
 - Refer to NFPA 2001 Standard on Clean Agent Fire Extinguishing System.
- ASHRAE Handbooks
- ASHRAE Standards
 - Mechanical ventilation system should be designed and installed according to the ASHRAE STANDARD (62-1999).
 - Air Filtration should be designed and installed according to the ASHRAE STANDARD (52-1996).
 - ASHRAE Standard 90.1 - 1999: Energy Standard for Buildings Except Low-Rise Residential Buildings.
- Carrier System Design Manual.
- Uniform Solar Energy Code
- SMACNA Duct Construction Standards
- ASPE Data Books
- Local codes and ordinances as may be applicable

Designer should submit a copy of the followed / specified standards to the AUB authorities.

4.2 Plumbing Work

4.2.1 Drainage

A. Design Criteria

- All existing underground drainage utilities that are known in the area should be indicated. These include piping, valves, manholes and pits. This coordination is necessary to avoid problems in the field of the relative location of the pipes being connected to.
- Sanitary drainage should be of the one pipe system where waste and soil drainage are conveyed together and properly vented. Sanitary drainage should be conveyed by gravity to the external sewer network. Drainage from basement floors below the invert level of the existing network

should be collected in sumps and then pumped up to the external sewer network.

- All roof, decks, canopies, balconies, terraces, etc., should be drained by gravity and led to the storm water network or other means of disposal. All areas below the drainage network level should drain by gravity to sump pits and be pumped up to the external network.
- No building should be designed with combined storm water and sanitary drainage systems. Each system must be completely independent.
- Extend house drains out of the building as often as necessary to maintain required headroom in the building, consistent with the availability of site or street sewers on a particular side of the building.
- Provide the building with ample stacks to serve the building requirements; maintain minimum offsetting of stacks and avoid long branches.
- Drainage piping should not be run in elevator machine rooms, telephone rooms containing telephone equipment, relays and terminal strips; electric rooms and closets containing exclusively equipment such as transformers, switchgear, motor control centers, panel boards computers and electronics equipment or similar items of equipment; and in emergency generator rooms, except for piping directly associated with the generator unit.
- Do not run drainage piping at the ceiling of kitchens, food preparation, food servicing, or food storage area, OR and other critical care units if possible.
- Coordinate with the HVAC design so that necessary floor drains, funnel drains, etc., are provided reasonably adjacent to all HVAC equipment requiring drains.
- Provide garage areas with floor drains to carry off the water dripping from the cars, to allow for hos-

ing of the floor, and to remove the sprinkler discharge.

- Provide ramps from the outside for entering and leaving the garage with full-width trench drains at the base and partway up the ramp.
- Garage floor drains should be minimum of 4-in outlet size.
- Horizontal piping serving two or more drains at the lowest level should be at least 5-in size for two drains and 6-in for three or more.
- Footing drain line around the building should be designed only in areas where the water table is high.
- Use oil separators for drainage system from generators room, and from garages.
- Neutralize wastes from all fixtures and equipment from laboratories where acids are or may be used before discharge to the sanitary drainage system using neutralizing pits.
- Grease traps should be installed for drainage of kitchens. Grease traps are to have floor access covers for ease of maintenance. Locate away from public areas and in locations providing easy access for both regular maintenance and pumper trucks.
- All pipe cleanout to be readily accessible. They shall be exposed in unfinished areas or of the floor or wall type in finished areas.
- Inlet piping and/or ventilated manhole cover (or grating) must be large enough to allow entrance into the pit of the peak capacity of the pumps.
- Sewage pump pits must be sealed and vented through the roof.
- Make sure that the electrical engineer provides waterproof type wiring for sump pumps.
- Where the lift is 35 to 40 ft or more, provide sump pumps with spring-loaded check valves instead of the regular swing checks used elsewhere.
- Keep roof drains and stacks through the roof 12 to 18 in away from all parapet walls, building off-

sets, roof openings, etc., to allow for proper flashing. All stacks through the roof should be at least 4-in in size.

- Do not use 2-in drains except for very small ledges, balconies and canopies, or where 3-in cannot be accommodated in the construction.
- Supply drains in areas subject to dirt and grit with a freestanding bucket in the drain body.

B. Outline Specifications

- Underground drainage piping should be cast iron soil pipe and fittings.
- Drainage piping inside the building should be of galvanized standard-weight steel pipe with threaded cast iron drainage fittings for 2-in and below, and cast iron soil pipe and fittings for 2 ½ - in and above.
- Vent pipes shall be galvanized steel.
- UPVC pipes and fittings to BS standards with sound barrier insulation could be an alternative to cast iron pipes subject to discussion and approval of AUB authorities.
- Storm drainage pipes shall be cast iron.
- Exposed rainwater pipes are to be galvanized (on the façade of the buildings). RC or GRP pipes could also be used for large storm drainage pipes (infrastructure).
- All waste piping from laboratory sinks and cup drains to acid neutralizing sumps and all vent piping for these fixtures should be of acid resistant material. Pyrex pipes shall be used for Laboratories drainage.
- Grease traps should be coated cast iron, sized in accordance with the manufacturer's recommendations, and provided with a flow-control device.
- Oil separators should be coated steel.
- Sump pump discharge piping, except underground should be galvanized standard weight steel pipe with threaded cast iron drainage fittings.

- All drains on surfaces not intended for promenade should have dome strainers; others should have flat strainers with free area equal to twice the outlet area.
- Sewage and sump pump should be normally submersible duplex (each full size).

4.2.2 Water Supply

A. Design Criteria

- Size piping and equipment to include future anticipated loads and to provide for normal flexibility in laboratory areas.
- Provide all risers with drain valves. Where possible, all drain valves discharge shall be piped to a near-by drain.
- All valves shall be accessible for equipment maintenance.
- Provide mains with sectionalizing valves at strategic locations such that each floor can be isolated independent of main building. In hospital-use buildings, where practical, loop mains and generously provide them with sectionalizing valves. Valve all connections for future extension.
- Peak flows in the piping should be calculated and the pipe sized by using fixture units and the proper friction curves and tables for the proper material.
- In providing water connections to the equipment, the connection should be as large as the connection on the equipment or larger if required to deliver the gpm required with reasonable pressure loss.

1. Cold Water Supply

- Provide all fixtures and equipment requiring water with water in adequate quantities and at required pressures.
- The water storage tank shall have a minimum of two independent compartments. Firewater requirements must be considered in sizing the water storage facility. The raw water quality may

dictate the need of one or more of the following modes of treatment as needed:

- Sand filtration
 - Softening plant
 - Chlorination
 - Reverse Osmosis
- Where no site mains are available, water supply must be developed from wells.
 - Provide boosted pressure systems when the municipality pressure of existing network cannot maintain the required pressure to all fixtures and equipment at peak flow 100 per cent of the time.
 - Provide hospital buildings, laboratory-use buildings, and boiler plants, with two services, fed from separate mains wherever possible.
 - Size each service for the full demand of the building.
 - All water systems shall be designed to include back flow prevention device. Back flow prevention devices shall be of the type used in hazardous applications (For Laboratories).
 - The cold water system must be designed to provide a minimum of 8-psig and a maximum pressure as per manufacturer pressure at any plumbing fixture. Water velocities in the piping system should not exceed 6 feet per second for quiet operation and where quick closing valves are installed, shock absorbing devices, must be added to prevent water hammer.
 - Provide pressure-reducing stations for lower zones of the building when its height produces excessive pressures.
 - Where a gravity house tank cannot be placed high enough to provide all the pressure requirements of fixtures and equipment on the topmost floors, a small constant-pressure system or hydro pneumatic pressure tank system pumping from the house tank should be provided to serve these fixtures and equipment.
 - The water consumption must be monitored per department by providing water meters connected

to BMS in order to control water use and reduce leakages.

- Water meters to be installed on the following services:
 - Main incoming water supply
 - Kitchen hot and cold water supply
 - Laundry hot and cold water supply
 - Domestic hot water supply
 - Cooling towers
 - Irrigation
 - Power / Steam Plants
 - Food Catering areas
- Provide hose bibs in all machinery rooms, kitchens, and rooms requiring washing down, and in rooms with floor drains. All hose bibs should be provided with vacuum breakers.
- Use cold water as potable since cold water is being chlorinated periodically.
- To have better services for high showering facilities like dormitories, residences and sports facilities, the collection of gray water (water from showers and wash basins) in suitable tanks should be considered. This water should then be filtered and used for toilet flushing.

2. Hot Water Supply

- Domestic hot water should be generated by means of a number of central hot water storage tanks. Hot water storage tanks will be heated by means of heating soft water supplied from the steam-to-hot water converters used for domestic hot water and space heating.
- Provide hot water circulated piping vertical and horizontal as required to supply all fixtures and equipment requiring hot water. Plan an orderly balanced system with an absolute minimum of sub-circulating loops or unreasonably complicated routing of mains.
- Provide automatic air-relief valves at all high points in the circulated hot water system that might become air bound. Where the need for

these air-relief valves is known, they should be indicated on the drawings, leaving the generality of the specifications to cover only the unforeseen need for them.

- When laying out hot water distribution systems, consider pipe expansion and contraction.

B. Outline Specifications

- Cold and potable water distribution pipes should be in copper. Alternative material is subject to discussion and approval from the AUB authorities.
- Hot water distribution pipes should be in copper. Alternative material is subject to discussion and approval from the AUB authorities.
- All hot water piping, circulation piping, tanks, fittings, and valves should be insulated.
- All hot water pipes shall be insulated with pre-formed sectionalized fiberglass insulation. The minimum insulation thickness to hot water piping shall be 25mm for pipes less than 50mm nominal bore and 38mm for pipes of 50mm and above. All insulated pipes shall be protected by fire rated canvas and sealant covering.
- Normal storage-type heaters should be set 20°F above the desired delivery temperature to allow for cooling down to desired delivery temperature as storage is used up. (Only approximately 65 to 70 % of tank volume is usable at or above the desired delivery temperature).
- The hot water circulating pumps should be all bronze pumps. They are normally in-line circulators, where available in the size and pressure rating required; otherwise they should be base-mounted compact flexible connected pumps.

4.2.3 Solar Heating For Domestic Hot Water

- The use of solar water heating should be restricted to residential projects or in facilities that have high domestic hot water needs such as dormitories, and sports facilities.
- Make sure the site has enough available sunshine to meet the needs efficiently and economically.

- The system should include collectors through which tap water is circulated and stored in a single tank, which contains the auxiliary heating source (normally an electric element).
- Sizing a solar water heater should involve determining the total collector area and the storage volume required to provide 100% of the household's hot water during the summer.

4.2.4 Water Treatment

A. Design Criteria

- Provide water treatment for cooling and heating systems, where necessary. Water treatment should be used to furnish a piece of equipment with water of the quality essential for its operation.
- Water treatment for hydronic systems shall consist of automatic feeding device to feed chemical solution into the piping systems to minimize corrosion, reduce build up of slime and scaling and microorganisms or other contaminants.
- Water quality test must be performed in order to select the optimum water treatment system that will elongate the life of the system and minimize water consumption especially for cooling towers.
- Degree of softening should be properly monitored to control and optimize the quality of soft water generated for the intended application.
- Limit copper piping carrying softened water to a maximum velocity of 5 fps.

B. Outline Specifications

- Water treatment pipes should be copper.
- Water softeners should be resin exchange units (usually with automatic regeneration) complete with brine tanks, interconnecting piping, and all required accessories and controls.
- Filters may be sand, diatomite, cartridge, or carbon type as required depending on the filtration job it has to do and the required quality of the effluent.

4.2.5 Medical Gases

A. Design Criteria

- Make ample provision in the supply source and in the piping for anticipated future building expansion.
- Locate the risers with relation to the areas to be served in order to achieve minimum length branches.
- Arrange the risers so that patient's outlets on the floor of any wing are divided between at least two risers. A valved branch should preferably serve no more than 12 patient's outlets.
- Provide the main supply line with a shutoff valve so located as to be accessible in an emergency.
- Provide each riser supplied from the main line with a shutoff valve adjacent to the riser connection.
- Provide each lateral branch line serving patient's room outlets with a shutoff valve that controls the flow to the patient room outlets.

1. Compressed Air

- Provide outlets, connected to a central system, in laboratories.
- The system should have rotary or screw liquid-ring-type compressors with receiver, filters, and constant pressure valve, delivering, dry, clean, oil-free and bacteria free air with a maximum 5-psi pressure drop in the piping, and to ensure a pressure of 60 psi at the outlets or 120 psi as needed.
- Provide lower-pressure requirements by pressure reducing valves. Provided isolated higher-pressure requirements by isolated and/or sub-central compressor units of the required pressure.
- Where especially dry air is requested or where the air piping runs through cold spaces, provide air dryers.
- Provide the branches feeding outlets grouped with other medical gas outlets with ball valves mounted in a common multiple valve box.

- Piping should be sized to include future anticipated loads.
- The compressed air demand should be based on the following:
 - Flow rate for laundry equipment as per manufacturers recommendations.
 - Diversity factors for various outlets should be applied while sizing the pipes.
- Base pipe size selection on the following
 - Maximum friction loss rate of 1-psi per 100 ft
 - Maximum friction loss to the farthest outlet of 5-psi
 - Maximum velocity of 4000 ft/min

2. Vacuum

- Provide inlets connected to a central system to serve patient treatment. Connect all inlets that serve patient treatment to a completely separate system from those serving the laboratory inlets.
- The central vacuum air plant should be located below the areas served with up-feed risers.
- The vacuum pump discharge should be run up through the roof remote from all compressed air and other intakes, windows, etc.
- All risers and branches should be valved. Mains should be provided with sectionalizing valves at strategic locations. All connections for future extension should be valved.
- Piping should be sized to include future anticipated loads.
- Base pipe size selection on the following
 - Maximum friction loss rate of 1-psi per 100 ft
 - Maximum friction loss to the farthest outlet of

4-in Hg

- Maximum velocity of 5000 ft/min

3. Oxygen

- Large installations should be supplied from a bulk oxygen tank. Small installations should be supplied from an oxygen cylinder manifold.

1 to 100 outlets Manifold

Over 100 outlets Bulk

- Base pipe size selection on the following
 - Maximum friction loss rate of 1-psi per 100 ft
 - Maximum friction loss to the farthest outlet of 5-psi.
- Outlet pressure should be a minimum of 50-psi and a maximum as recommended by Manufacturer.

4. Nitrous oxide

- Outside manifolds should be avoided due to cold weather operational problems.
- Base pipe size selection on the following
 - Maximum friction loss rate of 1-psi per 100 ft
 - Maximum friction loss to the farthest outlet of 5-psi.
- Outlet pressure should be a minimum of 50-psi.

B. Outline Specifications

- Pipe material shall be type L copper tubing with wrought copper or cast brass fittings with silver CP1 or CP4 brazed joints. All pipe, fittings, fittings and valves should be specially washed and manufactured for medical gas use and protected from contamination.
- Buried piping should be type K and adequately protected against frost, corrosion, and physical damage by installation within a pipe or conduit, and with proper cover.

- Control (shut-off) valves should be ball valves with locks.
- Check valves should be normally spring-loaded type for compressed air and soft-seated swing type for vacuum.

4.2.6 Liquefied Petroleum Gas

A. Design Criteria

- Provide LPG to kitchen equipment, laboratory outlets and elsewhere as required by the Physical Plant.
- Investigate carefully the requirements of equipment requiring gas; calculate the branch piping as well as the mains and risers on the basis of the requirements of the equipment. Loads for equipment should be taken from the manufacturer's ratings.
- A gas meter shall be provided to the building main supply.
- Base pipe-size selection on a maximum friction loss of 0.3-in of water from the meter to the farthest horizontal point of use. Consider 0.1-in of water gain per 15 ft of rise in sizing risers.
- Piping should be sized to include future anticipated loads.
- The demand and pipe sizes should be based on the following:
 - Flow rate of kitchen equipment as per manufacturers recommendations.
 - Diversity factor for various outlets.
- The bulk storage tanks should be sized to cater for two-week continuous operation.
- Gas piping should pitch back to the meter wherever possible. All risers and trapped sections should be provided with drip pockets consisting of nipple and cap.

- Wherever possible, gas mains and risers should be run exposed rather than concealed in shafts or hung ceilings. This is to prevent possible accumulation of gas in these closed spaces due to even minute leakage from the gas piping system, which may explode if in the proper concentration and subject to an ignition spark of any kind. Where it is impossible to keep this gas piping out of hung ceilings, shaft and wall recesses, provide some sort of ventilation for these spaces to prevent the possible accumulation of gas.
- Gas risers in airshafts must be encased or separated by masonry construction.
- Gas piping passing perpendicular through air plenum ceilings or ducts, without connections, should be sleeved for the full length.
- All risers and branches should be valved. Mains should be provided with sectionalizing valves at strategic locations. All connections for future extension should be valved.
- All underground pipes shall be pre-lagged to the required color and all joints color taped after installation.

B. Outline Specifications

- Pipe work shall be copper. The following minimum sizes shall be used:

| | |
|-------------------------|--------------|
| Servicing one outlet | ¾-in min |
| Servicing three outlets | 1-in min |
| Above three outlets | as required. |
- All joints shall be silver soldered.
- Isolation valves shall be of the ball type.

4.3 Fire Fighting System

A. Design Criteria

- Design fire fighting in full compliance with NFPA and local codes requirements.
 - Refer to NFPA 10 for fire extinguishing systems.
 - Refer to NFPA Standard 11 for foam fire protection system.
 - Refer to NFPA 13 and 14 for sprinklers system and fire standpipe systems respectively.
 - Refer to NFPA Standard 17 for dry chemical fire protection system & 17A for wet type.
 - Design clean agent fire extinguishing systems in accordance with NFPA 2001 and to totally flood the hazard areas with the required concentration.
- Refer to NFPA Standard 20 for data on fire pumps.
- Pipes should be sized using hydraulic calculation method in accordance with the recommendations of NFPA 13.
- Do not use fire fighting water pipes to supply water for other purposes.
- Sprinkler piping to be not less than 25 mm even if serving only one sprinkler.
- Flush and test connections to be provided at ends of cross and feed mains. Minimum size to be 25 mm.
- Provide valves on mains and branches for sectionalizing the system for maintenance and operation and for flushing, draining and testing the system.
- Provide 50 mm globe valve at base of every standpipe. Slope piping not less than 2% towards drain valves.
- Install alarm check valves on main water supply pipe to every fire fighting water distribution system at source of pressure. Install, test and adjust in accordance with manufacturer's instructions.
- Support horizontal pipes at intervals not exceeding 3 m.

- Support vertical pipes at every floor.
- Support cross-mains of sprinkler piping independently of branch line hangers. Provide one hanger on each length between branch lines.
- Install hangers without regard to location of pipe sleeves through walls. Center pipes in sleeves and do not use sleeves for pipe support. Attach to concrete ceilings with expansion bolts.
- Fire pump relief valve, when required, should be piped back into the suction, except where on-site storage tank is available.
- Pipe layout should be designed so as not to exceed the pressure limitations of sprinklers or fire standpipe. Where pressure limitation has been exceeded, listed pressure-reducing valves should be provided.
- Zone control valves shall only be installed in corridors, stairwells, mechanical rooms, fire pump rooms and sprinkler valve rooms and shall be easily accessible. The Zone control valves shall be accessible.
- Test and drain valves discharge shall be piped to a drain capable of handling the discharge at full flow or to the exterior of the building.

B. Outline Specifications

- Fire water pipes and fittings should be black steel, schedule 40.
- Check the use of clean agent fire extinguishing system with the AUB authorities.
- Pipes and fittings for clean agent fire extinguishing systems beyond manifold should be galvanized steel, seamless to ASTM A 53 or ASTM A 106, schedule 40. Fittings should be galvanized, malleable iron, class 300.
- Fabricate manifold from galvanized steel pipe and fittings to ASTM A 53 or ASTM A 106, schedule 40. Fittings to be class 300.
- Clean extinguishing agent should be low boiling, colorless, liquefied, compressed gas, having high density and low viscosity.

- Clean agent fire extinguishing storage cylinders should be floor-standing type, constructed of high strength steel alloy.
- Piping subject to alternate wetting and drying, such as drain dripping, test piping, Siamese connection between Siamese and check valve, and dry systems shall be galvanized.
- Sprinklers heads types should be selected in accordance with NFPA requirements and in co-ordination with interior decoration for areas that have decorative false ceilings.
- Hose nozzles should be adjustable fog type.
- Fire pump and jockey pump discharge check valves should be spring type when the lift to the top is 35 ft or more.
- For motor-driven pumps, select 3500 rpm rather than 1750 rpm whenever a choice is available.
- Control valves 6 in and larger, except at fire pumps should be provided with bypass valves.

4.4 Air Conditioning And Ventilation

A. Design Criteria

- Air-conditioning shall normally be provided by the use of large air-handling units or small fan coil units using chilled water supplied from a central chilled water plant.
- Direct-expansion (DX) refrigeration systems shall be used only where it can be demonstrated that required conditions cannot be achieved by use of chilled water or the area is of a critical nature e.g. computer, data or communication rooms.

1. Steam And Heating System

- The heating plant of each building should be selected to cater for the needs of space heating, hot water heating and steam supply for kitchen and laundry equipment.
- Since the existing steam central plant is designed to cater for future expansion, steam should be used as a source for the heating plant.

- The heating pipe work design will be made in accordance with ASHRAE recommendations and Carrier System Design Manual.

- The temperature and maximum velocities of the heating water should be based on the following parameters:

| | |
|-----------------------|----------------------|
| Temperatures: | |
| Heating water supply: | 180°F |
| Velocities: | |
| Heating water: | 6 ft/sec to 7 ft/sec |

- The heating plant should comprise the following:
 - Connection for external steam network distribution with steam meter and related accessories.
 - A set of steam-to-hot-water converters, sized to serve space heating system and hot water heating system.
 - Space heating circuits comprising a set of pumps with one of the pumps as standby.
 - Hot water heating circuit comprising a set of constant flow pumps with one pump as standby and all related pipe and accessories.

2. Cooling System

2.1 Chilled Water Distribution Network

- The chilled water pipe work design will be made in accordance with ASHRAE recommendations and Carrier System Design Manual.
- The temperature and maximum velocities of the chilled water and condenser water will be based on the following parameters:

| | |
|------------------------------|----------------------|
| Temperatures: | |
| Chilled water supply: | 42°F |
| Condenser water supply: | 85°F |
| Condenser water return: | 95°F |
| Velocities: | |
| Chilled and Condenser water: | 6 ft/sec to 7 ft/sec |

- Every project should follow the use of the packaged, double-effect water-cooled steam heated absorption chillers, with microprocessor-based controls complying with ASHRAE requirements.

- The use of other types of chillers (Air cooled packaged screw chillers) should be restricted to small projects. When used, chillers shall be supplied with OEM acoustic enclosures for compressors and for fans. Alternatively, Chillers with complete acoustic enclosures is a must to areas classified as being Noise-sensitive Areas (Close to Educational facilities).
- Perform a feasibility study resulting in the possibility of having chilled water plants to serve a complex of buildings. In this way load could be subdivided, and better efficiencies could be reached.
- Each chiller should be sized to cater for a part of the load. Spare capacity should be considered while sizing the chillers. If 3 chillers are to be installed, select the chillers to cater for 40% of the total load. If 2 chillers are to be installed, select the chillers to cater for 66% of the total load.
- Chillers are to be cooled with a set of cooling tower cells located on the roof of the building or outside.
- Any new or renovated building containing more than one chiller shall have a primary/secondary-chilled water pumping system.
 - The primary chilled water circuit should comprise a set of constant flow pumps with one of the pumps as standby, and related pipes and accessories.
 - The secondary chilled water system should comprise a set of secondary variable flow chilled water pumps serving the building. The secondary circuit could be divided into more than one circuit with its pumps and accessories depending on the functionality.
 - The condenser water circuit should comprise a set of constant flow condenser pumps with one of the pumps as standby, and all related pipes and accessories.
- Provide shut-off valves for all hydronic mains at all take-offs to mechanical rooms and pump rooms. Also provide shut-off valves at the supply and return side of all equipment to provide for removal and repair.

- Provide drain valves on bottom of chilled water pipe risers and automatic air vents with isolating valves on top of chilled water risers. All drain valves shall be piped to a near by drain.
- All water make-up assemblies shall be provided with a backflow preventor.
- Minimum individual chilled water pipe connection to fan coil units should be 20 mm.
- Provide Aluminum jacketing on chilled water pipes running on roof.
- Insulate all drain lines.
- All piping systems shall be thoroughly flushed out before placing in operation. This is especially critical for all hydronic systems. Hydronic systems shall be connected so as to by-pass the units before flushing begins and then flushed and the filters cleaned out at least three (3) times before the units are connected to the system and placed in operation. All cooling towers shall be completely cleaned and flushed after all systems are in operation and the site work has been completed.

2.2 Air-Handling And Fan Coil Units System

- Air-conditioning plant shall be designed to maintain the following internal design conditions:
 - Internal Design Conditions - Summer
 - 24°C DB +/- 1°C
 - 50% RH nominal
 - Unless specifically nominated otherwise.
 - Internal Design Conditions - Winter
 - 21°C +/- 1°C.
 - Unless specifically nominated otherwise
- While using in dependent fan coil units, provide them with a four pipe connections and a 2-way modulating control valves located above the false ceiling. In buildings other than the hospital, acoustic duct lining should be provided on the discharge of the fan coil units.

- Acoustic duct lining should be provided on the discharge and inlet of Air handling units to ensure acceptable attenuation of noise levels that are above standard limit of related codes.
- Introduce pre-treated outside air each fan coil unit from a central outside makeup air handling units.
- Introduce heat recovery in 100% fresh air units.
- All air-handling systems shall have adequate outdoor air drawn from outside the building via ductwork at locations well away from cooling towers discharges, fume exhausts or traffic.
- Each air-handling unit should be equipped with return air fans.
- Fan coil units shall be mounted below the ceiling or floor mounted while air-handling units shall be floor mounted in dedicated plant rooms or cupboards.
- Provide condensate drainpipes for air handling units to the nearest roof drain, and for fan coil units to the nearest floor drain.

3. Humidity Control

- Humidity control will not be provided unless specifically called for or where special circumstances dictate. Where special conditions are required these will be nominated by the user and agreed by the Physical Plant.

4. Heat Recovery

- Provide Heat recovery units by circulation of water to coils in the supply and exhaust air streams.
- Provide free cooling using outside air for systems serving internal areas due to the favorable weather during mid seasons. Free cooling is achieved by supplying the area with 100% outside cold air to offset the generated internal heat gains.

5. Noises And Vibration Control

- Coordinate placement of new mechanical rooms with architect to avoid locations next to sound sensitive spaces. Where necessary, coordinate

sound treatment of existing mechanical spaces with architect in renovation projects.

- The system shall be designed to eliminate the transmission of noise and vibration from air conditioning and mechanical equipment. Sound attenuators and/or insulated ductwork shall be installed where necessary to eliminate the transmission of fan noise.
- Perform sound calculations for all major sound producing equipment and air terminal units so that HVAC systems meet space NC program requirements.
- Care shall be taken to minimize the transmission of vibration to the structure from mechanical equipment. Where reciprocating or rotating equipment is installed this shall be isolated from the structure by vibration isolators. The maximum allowable noise rating levels are scheduled below or as per ASHRAE standards.

| Area | NR Levels (63 to 8000Hz) |
|--------------------|--------------------------|
| General Offices | NR 40 |
| Laboratories | NR 40 |
| Lecture Theatres | NR 35 |
| Seminar Rooms | NR 35 |
| Individual Offices | NR 40 |
| Library | NR 30-35 |

6. Ductwork And Registers

- All ductwork, supply, return and outside air shall be constructed in accordance with SMACNA standards.
- Design and size ductwork systems using SMACNA and ASHRAE criteria for velocities and fitting losses. Do not oversize ductwork unnecessarily to avoid performing sound calculations. Duct layouts should be optimized to perform within acceptable criteria at the lowest reasonable installed cost.
- In general, low velocity systems are preferred. Ductwork shall be designed to limit air velocities to a maximum of 6 m/s. However, main riser

ducts shall be capable of handling an increase of 15% in air quantity. Fans and motors should be selected with this in mind.

- Where return air ceiling plenums are used:
 - Collect return air at multiple central locations to avoid severe short-circuiting of air from large floor areas with single point return.
 - Provide transfer openings in walls that extend above ceiling to underside of structure to allow plenum air to transfer freely. Coordinate transfer openings with architect so that openings are shown on general construction drawings. Provide smoke and fire dampers in transfer openings where required by partition rating.
- Flexible duct is allowed at connections to supply diffusers and grilles. Maximum length of flexible duct is limited to 5 feet.
- Transfer ducts shall be sized for a duct velocity of 300-500 fpm.
- Size air terminal units for maximum and minimum airflows and inlet static pressures that are within the controllable range of the velocity reset controller.
- Locations of return grille above the fan coil units should have overlap with the units' location so as to allow proper withdrawal of filters and units.
- Provide bell mouth and aluminum wire mesh screen on fresh air intakes to air handling units on roof.
- Provide volume dampers in the branch ducts to allow for balancing of air during the testing and commissioning stage.
- To allow duct cleaning, provide duct access panels in the risers at each floor and in each branch or sub-branch. Duct access panels shall be not more than 10 meters apart. Duct access panels location above ceilings shall be coordinated with the ceiling grid, light fittings and equipment layout.

7. Mechanical Ventilation

- Mechanical ventilation shall be provided to meet ventilation codes and to remove obnoxious, toxic or vapor fumes. Ventilation for comfort purposes

should preferably be natural or provided by implementation of natural draft risers, wind driven roof ventilators, ceiling fans and operable wall louvers.

- Mechanical ventilation shall be provided for all toilet rooms, janitor's closets, and storage rooms where odors could become a problem. Group toilets shall have 2 CFM per square foot minimum ventilation.
- Minimum outside air ventilation should be at least 10% of the total supply air, 20 cfm/person, or makeup for exhaust air, whichever is the greatest.
- Check wind direction for the location of exhaust fans and air supply equipment on roof.
- Fresh air intakes shall be located a minimum of 25 ft away from sanitary sewer vent outlets, exhaust outlets and truck and bus loading areas.
- Thermostatically controlled ventilation should be provided in main electrical room to prevent excessively high temperatures.
- All spaces, which produce dust (cabinetry labs, etc.), shall be negatively pressurized to assist in reducing the infiltration of dust to adjacent spaces. Also, the mechanical systems for these spaces should have easily replaceable filtration systems.

8. Air Filtration

- Filtration efficiency for air handling systems serving occupied spaces should not be less than 30% dust spot efficiency as per ASHRAE 52.
- In most larger, standard buildings, the designer should be specifying 30% pre-filters with 60-85% final bag filters.
- Filtration for ventilation systems serving mechanical spaces or unoccupied areas may have efficiencies less than 30%.
- Filters for research facilities and hospitals with special filtration requirements (example: HEPA, bag-in/bag-out, etc.) should be specified according to established standards for these facilities.

- 30% pre-filters may be specified as panel type or roll type.
- Provide 1" thick throw away filters on intake air where outside air is used to ventilate utility and similar spaces (to prevent entry of insects).

9. Relative Room Pressure

- Positive or negative pressure to satisfy air movement and odors shall be achieved normally within the settings of the air balancing dampers at the time of commissioning the system.

10. Smoke Control

- Provide fire dampers in all wall penetrations for firewalls rated two hours or greater. A fire damper, labeled with standard UL 555, provides a break-away connection in ductwork within a fire-rated wall. A damper link will burn at 160°F and close the connection, maintaining the firewall barrier.
- Provide smoke dampers in all wall penetrations through smoke barriers and/or partitions. A smoke damper, labeled with standard UL555S, closes a duct connection within a wall when a coupled smoke detector is activated. Combination fire/smoke dampers provide breakaway connection under heat and/or smoke conditions. Independent fire and smoke dampers can be placed in sequence.
- Designs of HVAC systems more than 2,000 cfm in size are required to include smoke detectors in the discharge air duct. Designs of systems for more than 15,000 cfm require additional placement of smoke detectors and dampers in the HVAC discharge and return air paths.
- Smoke control, especially in multiple stories, requires an engineered fire strategy that will put the fire floor under negative air pressure, while the floors above and below are positively supplied. Each floor in a building must be sized for smoke exhaust, where to exhaust, and if dedicated fan equipment is required in addition to the building ventilation capacity.
- A gravity smoke ventilation system employing an elevator shaft would include smoke dampers at

each floor. Smoke detection on a floor would open the damper to release positive flow air to the shaft for exit at the roof.

- Stairwell pressurization, to create smoke-free exit passageways, requires multiple supply air outlets throughout the full height of the stairwell. All building joints surrounding the stairwell must be sealed. In special design cases, like a building atrium, smoke and fire safety guidelines will include fire exhaust as well as makeup air supply.

11. Maintenance

- All equipment and equipment rooms shall be designed to ensure adequate provisions for maintenance. Special consideration shall be given to ensure proper clearances for maintenance of filters and removal of chiller and boiler tubes, fan housings, and fan shafts.
- Access to equipment for service and maintenance shall be thoroughly coordinated. Required clearances shall be specifically identified on the drawings (for equipment such as fan coils, VAV boxes, air handling units, control panels, etc.). Coordinate with other disciplines to ensure that other trades (electrical, fire sprinkler, etc.) are made aware of the required clearances.
- Design of mechanical shafts shall be carefully set in order to ensure ample space for the installation and maintenance of all utilities that are routed inside the shafts.

B. Outline Specifications

- Air-conditioning and mechanical ventilation duct material should be as follows:

| | |
|-----------------------------|------------------|
| (Rigid) | Galvanized steel |
| (Flexible) | Aluminum |
| Fume exhaust/fume cupboards | UPVC |
| Kitchen Exhaust Hoods | Stainless steel |
- Joints in exposed ductwork shall be, pocket and tail joints or similar to provide a smooth neat appearance.
- Rigid fiberglass board ductwork and fiberglass insulation shall not be used. Ductwork insulation

shall be external wherever possible. Where ductwork and equipment has internal insulation shall be lined with perforated metal so as not to expose the insulation directly to the air stream.

- Exhaust ducts in the laundry areas should be insulated to avoid heat stratification in the space.
- In general, chillers should be packaged, double-effect water-cooled absorption chillers with a steam heat source, with microprocessor-based controls complying with ASHRAE requirements.
- Other alternatives could be Centrifugal water chillers, packaged, water cooled, electric-motor-driven, rotary-screw water chillers with motor controller and microprocessor-based controls complying with ASHRAE requirements.
- Primary and secondary pumps for chilled and heating water circuits should be of the centrifugal end-suction type.
- Condenser pumps should be of the centrifugal split case type.
- Air handling unit fans should be specified to mid-range speed instead of near maximum. (Units are coming apart at high speed). Units should be sized so the motor will be smaller horsepower than the maximum allowed for fan size.
- Drain pans in air handling units and fan coil units shall be double layer insulated, tilted in two directions so it will drain no matter how the unit is set.

4.5 Building Management System

- The Building Management System shall be compatible with the existing system.
- The system should be a fully integrated building management system (BMS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, including color graphic workstations. System major elements include, without being limited to, the following:

- Central processing units.
- Personal computer operator workstations.
- Data storage units.
- Stand-alone Data terminal units.
- Data communication units.
- Stand-alone Remote control units.
- Portable operator's terminals
- Data interface units.
- Communication cable.
- System software.
- Console.
- Uninterruptible power supply (UPS).

4.5.1 System Description

- Building Management System: Distributed process control system consisting of central control, central communications, and remote control systems to monitor and control the following building systems:
 - Heating, ventilating, and air conditioning systems control.
 - Smoke control.
 - Energy management.
 - Plumbing systems control
 - Building and exterior lighting.
 - Fire alarm and detection.
 - Intrusion detection and security access.
 - Emergency power generator
 - Electric intake resources including Medium Voltage switchgear, power transformers, and Low Voltage Switchgear
 - Elevators
 - Fuel systems
 - Uninterruptible power supply systems (UPSs)
 - Preventive maintenance scheduling

4.5.2 Future System Expansion

- Design system to be expanded to accommodate 50 % additional input/output points and related expanded database, without hardware or software. Design application software programs and system database to be transportable to expanded central processing unit if required to accommodate specified future expansion.

4.6 Mechanical Site Utility Works

A. Design Criteria

1. Steam Plant

- Steam should be used to feed the steam-operated equipment of laundry, kitchen, the absorption cooling units, and other steam driven equipment.

1.1 Steam Boilers

- Steam boilers should be of the fully packaged type, high pressure, and horizontal fire tube, designed and constructed with latest ASME code.
- Steam Boiler should have the following trim:
 - Pressure controllers.
 - Safety Relief Valve: ASME rated.
 - Pressure gage.
 - Water column.
 - Drain valves.
 - Blow down valves.
 - Stop valves.
 - Stop-check valves.

1.2 Steam And Condensate Accessories

- Provide related steam specialties including boiler blowdown, boiler feed units, condensate return units, pressure reducing stations, and pipes and accessories.
- Steam traps should be provided to maintain steam dryness.
- Steam traps should be specified with monitoring

chambers.

1.3 Water Make Up And Treatment

- Treatment systems should include water softeners and chemical dosing units.

2. Steam Distribution

2.1 Pipe Network

- Steam should be supplied from the central steam plant through an external distribution network.
- Exterior steam and condensate lines shall be installed in semi-accessible precast concrete tunnels or fully accessible concrete utility tunnels. The use of exposed steam pipes is prohibited.
- Expansion loops and anchor points should be used all over the network to allow for expansion of pipes.
- Steam network inside buildings should feed hot water converters that provide heating water to the space heating and hot water heating networks through separate circulating pumps.
- Condensate should be collected through condensate return units that pumps the condensate back to the steam plant through the condensate pipe network.
- All steam, condensate, lines within the building envelope shall be properly insulated.

2.2 Network Accessories

- All new buildings are required to be provided with steam meters.
- Condensate meters should be placed on the discharge side of the condensate pump. A three-valve bypass around meters should be provided. Where condensate return is by gravity, a gravity type meter may be considered.
- Where ever possible, steam and condensate piping shall be installed in such a manner as to allow for gravity return of condensate. The designer is to provide drip lines and air vents as needed to assure ease of operation.

2.3 Building Connections

- Coordination with the Physical Plant should be done for the most recent information.
- Expansion compensation on all new steam piping should be provided.
- All connections to mains shall be valved, both at the connection to the main and at the building.

3. Steam Production

3.1 Winter/Summer Consumption

- The Physical Plant should prepare on a monthly basis the rate of steam production, out of these is the following:
 - Steam charges that shows the rate of steam production with the corresponding charges for each building or group of building.
 - Steam production for a typical day in summer and winter.
 - Monthly steam production that shows the overall steam production for each month.

3.2 Optimization

- Optimize excess air in the boiler to increase steam generation efficiency. Boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F reduction in stack gas temperature. Good measurements of fuel flow and air flows are required to do this as well as good stack gas analysis.
- Optimize boiler blow down to reduce Total Dissolved Solids (TDS) in the boiler system.
- Optimize your boiler control system to optimize steam generation efficiency. Before you do this, make sure that the logic diagrams actually reflect what is wired into the system and that all the components of this system make sense and work.
- Ensure that an effective water treatment system is in place.

4. Drainage outside buildings

- Perform periodic maintenance of the external storm water and sewerage networks to prevent

blockage and overflowing of pipes and gutters.

- Lay pipes to uniform slope not exceeding 3% and true to line and grade.
- Lay pipes at not less than 600 mm below finished grade and not closer than 1 m to bearing walls and footings.
- Free vertical drop of sewer pipe into manhole should not exceed 450 mm from invert of pipe to invert of manhole.
- Connections to manholes, city sewers or other underground structure: make in a watertight approved manner. Full circle of pipe is to be visible at manhole.
- Provide connections to existing systems with minimum disturbance to existing lines. Existing pipes or structures damaged whilst making connections are to be replaced or reconstructed to the Physical Plant satisfaction at no extra cost.

5. Site Water Network

- A great care should be considered to solve the problem of water shortage. Two alternatives could be considered.

5.1 Deep wells

- Consider the feasibility of extracting water from deep wells. Design should be based on accurate researches on the geological status of the area. These studies and researches should provide the enough information about the best location of the deep well.

5.2 Reverse Osmosis Plant

- Install a reverse osmosis plant to treat the brackish water from the wells being used at present for irrigation or from similar new wells.
- Water analysis of well water should be conducted during well testing and drilling; however, due to the proximity of the site from the sea, the well water should be considered as sea water and design should be based accordingly.
- The product water required should be potable water, complying with the "World Health

Organization" Standards including WHO fluoride limits.

- The RO plant should basically consist of the following major components:
 1. Borehole pumps and wells. One pump should be as standby.
 2. Water reservoir for raw water.
 3. Sand filters and pumps.
 4. Micro filters.
 5. Pre-treatment equipment.
 6. Reverse osmosis units.
 7. Post chlorination and chemical treatment.
 8. Instrumentation and controls.
 9. Central control and monitoring system.
 10. Potable water reservoir.
 11. Potable water pumps and associated supply pipe work. One pump should be as standby.
 12. Electric power diesel generator with future standby option.

The Reverse Osmosis plant is practically more suitable.

B. Outline Specifications

- Steam pipes should be black steel, schedule 40.
- Drainage pipes outside buildings should be non-pressure PVC to BS 4660 for 110 mm and 160 mm pipes and to BS 3506 for 200 mm pipes and above, with rubber sealing rings and drilled in accordance with BS 65 and BS 540.
- Main drains leaving building should be non-pressure PVC underground pipes to inspection chambers.
- Pipes between inspection chamber and sewage disposal system to be non pressure PVC underground pipes.

Reverse Osmosis Plant

- Well pumps should all be of the stainless steel construction submersible motor well type.
- Filter booster pumps should be of the split case centrifugal type of stainless steel construction.
- Sand filters should be of the high flow rate, sand filter, pressure type hydrostatically tested at the factory to the specified test pressures.
- R.O. Units to be designed for seawater applications prepackaged and tested at the factory.

Central Control and Monitoring System to be desk mounted type, to automatically control and monitor the operation of the system as well as initiating alarm conditions with continuous chart read-out and print functions for quality of both feed and product water.

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