

MIT

Design Standards

DIVISION 26 — Electrical

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of Facilities

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1. ELECTRICAL SYSTEMS GENERAL REQUIREMENTS

1.1 Electrical Systems Mission Statement

The choice of equipment and the design of the installation should match or exceed the anticipated life span of the space or the building being designed.

Preference should be given to standard equipment and devices that are not customized or specialized in order to provide the level of reliability, accessibility, and maintainability as described in ASHRAE.

Interchangeability and expandability of devices and equipment is required.

As an institute of technology, MIT is always open to new ideas with consideration given to cost, maintenance and safety.

MIT promotes electrical designs and installations that minimize energy usage, maximize quality of illumination, and are not constructed with environmentally damaging materials. Recyclability of materials is an important factor to consider..

1.2 List of Supplemental Requirements

1. Service equipment shall be above the 26 foot City of Cambridge Datum point and below the fifth floor. Otherwise, measure and storm hardening techniques shall be taken to minimize equipment damage due to storms and floods.
2. New systems (including panelboards, terminal capacity, raceway, physical space) shall be expandable with at least 25 percent spare capacity.
3. User equipment shall be located in user spaces. Equipment for dedicated user shall not be located in base building department of facilities spaces.
4. Adequate receptacle and circuit coverage shall be provided. Receptacle plan shall be reviewed with end-users.
5. In labs, conduits shall be used between panelboards and surface mounted raceways to allow for future fill capacity and flexibility for modifying circuiting.
6. Provide grounding means in labs and fume hoods for instrumentation equipment comprised of ground stud or ground bar. Connection via #6 min AWG and green insulated ground to building steel or local panel equipment ground bar.
7. Equipment nameplates shall be provided for all distribution equipment including; panelboards, disconnects for mechanical equipment such a fan coil units, fans, roof top units, variable frequency drives, heaters, etc. The nameplates shall follow existing building standards or MIT standards. Nameplates shall include equipment name, voltage, source equipment name and location. (e.g. FED FROM DP1, ROOM 2-001). Equipment

- phenolic engraved nameplates shall be provided for all electrical equipment and fire pump tap section, feeder tap and splice, as follows: Normal Power – white letters on black field; Life Safety and Legally Required Power – white letters on red field; Optional Standby Power – white letters on orange field.
8. There shall be a naming convention for new equipment. The convention shall be similar to the following:
 - a. Building Name: 36.
 - b. Building Room: 029E.
 - c. Building System: ‘E’ EMERGENCY, ‘ ‘ NORMAL, ‘OS’ OPTIONAL STANDBY, ‘LR’ LEGALLY REQUIRED.
 - d. Building Equipment: ‘DP’ DISTRIBUTION PANEL, ‘P’ PANEL, ‘DS’ DISCONNECT, ‘XFMR’ TRANSFORMER, ETC.
 - e. System Voltage: 4’ 480/277V, ‘2’ 208/120V
 - f. Number in Series: 1, 2,3.
 9. Equipment, devices and circuits shall be labeled. Labels shall include the room number of the equipment serving the device.
 10. Steel fittings shall be used on raceways. Do not use die-cast.
 11. All wiring shall be stranded wire with the exception of MI Cable.
 12. Corridor, electrical rooms and mechanical room luminaires shall be provided with both normal-fed fixtures and emergency-fed fixtures.
 13. All terminations, connections and splices shall be per the National Electric Code and manufacturer’s requirements.
 14. Shared neutrals shall not be used.
 15. All electrical rooms shall have crash bar hardware and card access. Main electric rooms shall have high and low exit signs at egress doors.
 16. Review utility connections with the MIT campus electrical distribution system with the MIT Utilities Group.
 17. Always refer to the current Thematic Folder for Classrooms and Lecture Hall for additional requirements for electrical systems.
 18. Consideration shall be given to fan coil units and their associated condensate pumps. Fan coil units should not run without the condensate pump. When possible, they shall be circuited together or signage shall be provided that one should not run without the other.

1.3 MEP Equipment Naming Standards

Comply with the MEP Equipment Naming Standard in Division 22 - Plumbing, Par 4.3.

2. DESIGN REVIEW CHECKLISTS

The Design Consultant is responsible for filling out, signing, and submitting this information at each phase of design as a guide for review by MIT Facilities Engineering Group. The following sections outline the items which are expected to be submitted at each phase of the design process.

2.1 Schematic Design

MIT will use this submittal to develop comprehensive cost scoping for project budget development. In addition to information noted below, the documents shall include statements of conditions, known and unknown, that could affect project cost (i.e. This portion of the ceiling is extremely tight and may require relocation of some existing services or length of corridor may require multiple FA closets depending on length of wire runs and exact placement of equipment)

It is the intent of MIT that these documents identify areas of cost implication that the contractor can use to identify scope and cost that can be tracked through future phases of development.

Provide the following information in the Schematic Design submittal:

1. Review of applicable code, regulations, and standards.
2. State applicable codes on the cover drawing.
3. Identify major equipment.
4. Identify space requirements.
5. System descriptions (Basis of Design).
6. Alternative design concepts.
7. Outline specifications.
8. Equipment cut sheets.
9. Statement of probably costs (vendor assistance may be required.).
10. Preliminary motor and load list shall include, when applicable:
 - a. Lighting
 - b. Power
 - c. HVAC
 - d. Elevators
 - e. Fire Pump
 - f. Emergency Life Safety
 - g. Legally Required Loads
 - h. Optional Standby Loads
11. Engineering/generator sizing calculations including step loads:
 - a. Life safety.
 - b. Legally required.
 - c. Optional standby.
12. Preliminary watt/SF lighting, receptacle, HVAC, and special purpose loads including support documentation for selection.
13. Preliminary electrical distribution riser diagram:
 - a. Show approximate configuration.
 - b. Show preliminary distribution equipment sizes for substations and panels.
 - c. Provide for substations: voltage, bus ratings and transformer sizes.

14. Initial short circuit currents and short circuit bracing for equipment. Contact MIT Utilities for requirements.
15. Programming:
 - a. Service entrance requirements.
 - b. Service provider (MIT or Eversource).
 - c. Existing conditions plan
16. Overall oneline diagram.

Signature of Responsible Electrical Engineer _____

Dated _____

2.2 Design Development

Provide the following information in the Design Development submittal. It shall include a further development of all items in the schematic design:

Provide the following information in the Design Development submittal:

1. Final plans including:
 - a. Substation and panel final breaker frame sizes and trip sizes.
 - b. Final conduit and wire schedules.
 - c. Final panelboard schedules with final and per phase loads.
 - d. Final lighting fixture schedules.
 - e. Final engine/generator sizes.
 - f. Final risers and one line diagrams for power distribution system.
 - g. Final risers for fire alarm system and communication system.
2. Final specifications.
3. Final motor and load list.
4. Completed preliminary short circuit and coordination analysis.
5. Lighting calculations including photometric plots for unique and typical areas.
6. Voltage drop calculations.

Signature of Responsible Electrical Engineer _____

Dated _____

2.3 90 % Construction Documents and Construction Documents (CD) Phase

Provide the following information in the 90 % Construction Documents and Construction Documents (CD) Phase submittal. It shall include a further development of all items in the previous design phases:

1. List of changes and deviations from Design Development
2. Drawing List and Table of Contents
3. Graphic Scales
4. Building locus
5. Drawings coordinated with other trades
6. Drawings and specifications coordinated

2.4 Bid Documents

Provide the following information in the Bid Document submittal:

1. Bid package including specifications and stamped drawings.
2. List of deviations or changes from the 100% design development submittal.
3. Plans, specifications and calculations have been reviewed.

Signature of Responsible Electrical Engineer _____

Dated _____

3. ELECTRICAL DESIGN AND CONSTRUCTION GUIDELINES

3.1 Electrical Studies

The following electrical studies are required for all new buildings and large renovation projects. Refer to Appendix D for sample specification.

1. Provide arc flash hazard analysis study.
2. Provide short circuit and coordination study.
3. Provide short circuit device and evaluation study.
4. Protection coordination studies involving building primary service protection must coordinate back through the campus loop with the MIT Central Utility Plant Overcurrent Protection Devices. The CUP has two types of protection device, and any building can be fed from either or both. Therefore protection must be coordinated with both devices. The MIT Utilities Group will provide SKM library files for each of the devices.
5. The MIT Campus Distribution system can be sourced in multiple configurations.

Consequently, there is not one fault current and X/R value for each building. The MIT Utilities Group will provide three values for each building: maximum fault current, minimum fault current, and normal operating fault current and X/R.

- a. The maximum fault current value should be used to set device duty ratings within the building.
 - b. The engineer shall check the arc flash value for each of the three fault current values and use the highest energy level at each device for labeling purposes.
Note that the highest fault current may not provide the highest energy level.
6. In the event that an existing building is not connected to the campus distribution system at the location, MIT will provide max., min., and normal fault current levels for the loop buildings on either side. The engineer will need to check all values to insure proper duty and labeling.

Electrical studies shall be performed in SKM by Commonwealth of Massachusetts licensed professional engineer. Provide 24x36 as-built construction document quality AutoCAD and hard copy SKM risers. Require mounting of 1 hard copy on foam board with clear laminate along with construction document one line drawings in main electric/substation room and main emergency electric room. SKM files shall be turned over to MIT SEG and FIS after necessary revisions have been included.

3.2 Building and Electrical Codes

Refer to the most current codes from the City of Cambridge at the following link:

<https://www.cambridgema.gov/inspection/codesandmaps/Codes.aspx>

1. Building Codes: 780 CMR Building Code Massachusetts State Building Code, Basic/Commercial Massachusetts amendments to the International Building Code, Latest Edition
2. Energy Codes: Stretch Energy Code
3. Electrical Codes: 527 CMR 12 Massachusetts Electric Code, Latest Edition

Meet or exceed requirements within FM Data Sheets, 2015. MIT's Underwriter is FM Global which has design and product requirements that must be adhered to. These requirements often exceed the requirements of the NFPA and Building Codes. FM Global now posts all of its data sheets online at www.fmglobaldatasheets.com. The appropriate FM Global data sheets must be reviewed during the schematic and design development phases of a project to ensure requirements for a particular project are incorporated into the design. The Engineering Design Professional must submit the basis of design, working drawings and relevant calculations for review and approval of the FM loss prevention consultant in addition to review by MIT. Further and of important note, all MIT facility designs are reviewed by FM Global for acceptance and/or comment.

3.3 Removal and Abandoned Equipment and Wiring

Equipment that is being removed shall be provided to MIT, unless removal by others is approved, or unless directed otherwise by MIT Repair and Maintenance.

Any unused wiring effected by renovation work as a result of demolition or change in circuit requirements shall be removed back to the branch circuit protective device – and such device shall be identified as a spare.

No unused circuit wiring shall be left in any junction box unless it is designated and identified as spare or future wiring.

3.4 Underground Structures, Ductbanks, Cabling, Load Break Loop Switches

Refer to Division 33, Utilities Design Standards.

3.5 Main Electrical Room

1. Lighting fixtures shall be powered from the emergency and normal system in the building. The fixtures are to be located in locations that are not directly above the substation. Additionally, wall mounted battery-pack emergency lighting units shall be located in front of the substation with the heads pointed at the front and along egress paths. Lighting shall be switched at each entrance.
2. There shall be both emergency powered receptacles and normal powered receptacles in the room. Emergency powered receptacles shall be colored red.
3. A telephone outlet shall be provided in the room at 54 inches AFF adjacent to the exit door on the latch side.
4. Room shall have at least one double door. Doors shall be self-closing with panic hardware - notify architect of this requirement.
5. Except for sprinkler branch protection, there shall be no foreign systems that are not associated with the substations located in the rooms. For example, ventilation ductwork passing through the substation room that does not serve the room will not be allowed.
6. A housekeeping pad shall be provided under the substation and shall be a minimum of 4-inches high
7. In basement electric rooms sump pumps shall be provided.

3.6 Electrical Distribution

Card access and panic buttons are required for all main electrical rooms. Contact MIT Utilities for current implementation requirements. As-built drawings shall be provided with close out documents.

New or renovated critical buildings

Where critical buildings require new service entrance equipment, double-ended substations shall be provided. They shall be rated for manual closed transition.

New or renovated non-critical buildings:

Where non-critical buildings require new service entrance equipment based on the mission and day to day operations of the facility, the internal MIT team shall evaluate the need for either a single-ended or double-ended substation for the new facility.

New or renovated non-critical buildings less than 500 KVA:

Where non-critical buildings require new service entrance equipment and less than 500KVA, a Unitized Power Center or Package Unit Substation may be considered.

Electrical LED indicating lights shall be:

- Red = Closed
- Green = Open.

3.7 Substations

Substation and service related equipment shall be above the 26 foot City of Cambridge Datum point and below the fifth floor. All substations shall be double-ended and capable of manual closed transition.

Card access and panic buttons are required for all main electrical rooms. Contact MIT Utilities for current implementation requirements.

Construction of the substations shall be as follows:

1. In general, each unit substation shall be fully rated, with an incoming metal-clad vacuum circuit breaker with a transient voltage resistance transformer utilizing vacuum cast coil (VCC) type transformer and low voltage draw-out switchgear. Alternatively, metal-clad vacuum circuit breaker with RC Snubber and VPE dry type transformer.
2. For snubber applications, the snubber shall consist of the following features.
 - a. Three green LED indication lights (one per phase) to indicate the correct operation of the fuse. Illumination = the fuse is OK.
 - b. In addition to the front status indication lights, a set of remote alarm contacts shall be provided to signal the failure of the fuse and/or the capacitor (one per phase).

- c. Control power for the monitoring panel shall be 120VAC and shall be supplied from a control power transformer in the MV Transformer or the control power can be derived from the LV switchgear.
3. Switchgear shall have the following features or include provisions for:
 - a. Rated for 15 KV for 13.8kv equipment.
 - b. Remote operation of all circuit breakers (MV and LV) via either remote panel or delay pistol grip operation. If a remote panel is used the layout shall mimic the arrangement of the switchgear. The remote panel shall have a steel door with a tempered glass window kit.

Switchgear shall have the following features or include provisions for:

1. Rated for 15 KV (as required).
2. Provide Ground Ball Studs to the load side of Medium voltage circuit breakers. AB Chance C4060416.
3. Provide ground ball studs at the low voltage main circuit breaker on the line side.
4. Electric racking motor with a 20 ft or longer remote switch cable for main and all feeder circuit breakers.
5. IR inspection windows, Fluke-CV-300 or equivalent, to be provided to allow viewing of all cable connection points and flexible bus connections.
6. Strip Heaters.
7. Modbus connection for metering and monitoring.
8. Compression Lugs.
9. LED push to test lamps.
10. Power meter with display.
11. Communications card/Gateway.
12. Breaker lift truck.
13. Full height hinged main door with a foot operated door stop.
14. Hinged grounded metal safety barrier.
15. Insulated with non-hygroscopic insulation.
16. Switch interlock.
17. Permanent switch position indicator.
18. Rating nameplate.
19. Remote operation of all circuit breakers (MV and LV) via either remote panel or delay pistol grip operation. If a remote panel is used the layout shall mimic the arrangement of the switchgear.

Switchgear requires Factory Witness Testing of all switchgear before it leaves the factory. Witness Testing may be conducted remotely.

Transformer shall have the following features or include provision for:

1. Delta connected on the primary and rated 13,800V or as required by the rating of the primary system.
2. Wye connected on the secondary rated either 480/277v or 208/120V as required by the application.
3. Transient voltage resistant transformer, utilizing vacuum cast coils (VCC). Alternatively, VPE vacuum pressure impregnation and encapsulation (or Cast Coil) with RC snubber included.
4. 80 degree C maximum rise.
5. 220 degree class insulation system.
6. Copper windings and bus.
7. Copper ground bus.
8. Fan cooled. The fan cooling package to include digital winding temperature for each phase.
9. Fully ventilated louvers.
10. Flexible bolted link primary taps.
11. Rating nameplate.

Draw-out switchgear shall include:

1. Fully rated and fully draw-out metal enclosed air circuit breakers with two step stored energy closing mechanisms and electrically operated rack-out mechanism.
2. Bussing shall be tin plated copper.
3. TVSS shall be provided on each main breaker at each end of the switchgear.
4. Arc Reduction Maintenance switches.
5. Overhead breaker removal crane.
6. Hinged doors.
7. RMS digital trip units and discrete metering package with Mod Bus compatibility. Standard meter is GE Multilin PQMII-T20-A with MODBUS or approved equal by Schneider/Square D (PM 8000) or Eaton.
8. The main breaker(s) and tie breaker shall be draw-out type and the same frame size.
9. Feeder breakers shall be draw-out type with one exception:
 - a. If the application is approved by the Facilities Department, small loads can be powered by molded case feeder breakers.
10. Ground fault sensing shall be installed the main breakers, tie breakers and feeder breakers. The emergency system and legally required systems will have ground fault indication.
11. The main breakers and the tie breaker on the double-ended substation shall not be Kirk-Keyed together. Provide for a closed-transition scheme with a timer. After the timer times out (0.6 – 60 min) during maintenance, one of the 3 breakers would be tripped off to limit the duration that the gear is fed by more than one source.

12. Minimize the quantity of feeder breaker sizes to allow for interchangeability.
13. 15% minimum spare circuit breakers shall be provided.
14. Each feeder circuit shall supply power to only one primary distribution panel.
15. Solid state micro-processor based electric Meter shall be installed on unit substation main breakers. The meter shall have an RS232 communication port and an RS485 communication port with OPEN (and not vendor-proprietary) Modbus protocol. Electric parameters available from OPEN Modbus registers should include: voltage, current, energy consumption, real power, reactive power, apparent power, frequency, and power factor.
16. Feeder circuit breakers can use the trip units for the metering functions.
17. Electronic Check Metering System: Please add to specifications “All new installations shall use solid core current transformers and shorting blocks located in the meter compartments so the meters can easily be changed.”
18. Infra-red view ports shall be provided in the rear covers HI and LOW where cable connections are made.
19. Infra-red view ports will be installed at the point of incoming cables.
20. Ground ball studs shall be AB Chance C600-2102 and covers are C4060416.
21. If new switchgear is being installed, the meter installed in front of the main breaker shall be revenue grade. All breakers in the switchgear shall have Modbus communications included and factory wired.

Drawout Style Replacement Circuit Breakers, 600 Amp Frame and Larger:

1. If the project scope requires a connection to an existing circuit breaker (drawout style, 600 Amp Frame and larger) the circuit breaker must be overhauled and a new protection device (must be either a Entelliguard Trip Unit by GE or an AC Pro Tripp II by Utility Relay Company) shall be provided through one of MIT’s approved vendors. Trip functions and settings shall be determined by the engineer of record. Test reports shall be provided prior to shipment from the factory. Coordination settings must be provided to MIT and approved before this circuit breaker will be permitted to carry load current. Approved circuit breaker overhaul and conversion kit installing vendors: CBSNE & EESCO.
2. An alternative is to have a contractor provide a new retrofit drawout circuit breaker to take the place of the original drawout circuit breaker. This not only replaces the circuit breaker, but it also give MIT a new means for racking in and out. Acceptable manufacturers are Square D/Schneider Electric, General Electric, Eaton/Cutler Hammer. We have several examples installed across the campus already.

Buildings with Electrical Services provided by the Public Utility:

3. Determination of electrical service shall be decided by MIT Utilities.
4. Service from the electrical public utility shall be provided with transformers determined

by MIT Utilities. The service from the transformer is to be brought to distribution switchgear meeting the requirements of the switchgear section for double-ended and single-ended substations.

5. Auto-Power factor correction and transient voltage surge protection on the service shall be provided.
6. The design and layout of the electrical room shall meet the requirements as listed under double-ended and single-ended substations section.

3.8 Emergency, Legally Required and Optional Standby Systems

In addition to code mandated emergency and legally required loads, the following shall be powered from the emergency generator as a minimum and where applicable:

1. Selected critical research exhaust systems.
2. Selected critical research and systems.

In engine/generator rooms, battery-pack wall emergency lighting units shall be provided with lighting fixtures directed at the automatic transfer switch and at the generator control panel.

The batteries for the generator shall be located in a battery cabinet.

Generators and main emergency equipment shall be above the 26 foot City of Cambridge Datum point.

Engine-generator sets shall have the following construction:

1. All engine-generators shall be diesel powered.
2. Generator shall be manufactured by: Caterpillar or Cummins.

The following shall be powered from the emergency generator as a minimum and where applicable:

1. Elevators.
2. Life safety system including emergency lighting, exit signage and fire alarm system.
3. Fire pumps.
4. Smoke exhaust fans.
5. Critical research exhaust systems.
6. Critical research and systems.
7. Sump pumps.
8. Sewage ejection pumps.
9. IT network, Tel/Data closets.
10. BMS controlled servers.
11. MIT Security and parking control devices.

In buildings that do not have double-ended substations to provide redundancy, below are loads that shall be added to the generator optional standby system.

1. For dormitories:
 - a. Lighting in the suite
 - i. Living
 - ii. Kitchen space,
 - iii. Hallways,
 - iv. Bathroom
 - b. Power for 3 to 4 outlets per suite for charging phones and laptops.
 - c. HVAC
 - i. Domestic HW heater(s) controls.
 - ii. All pneumatic and electric control valves, including air compressors.
 - iii. The BMS system should have UPS and backup standby power.
 - iv. IS&T equipment rooms and corresponding a/c units.
 - v. A/C unit for High Voltage room
2. For office, classroom, and laboratory buildings:
 - a. Lighting in the common spaces
 - i. Living
 - ii. Break room spaces,
 - iii. Hallways,
 - iv. Bathroom
 - b. Selective receptacles for power to staff computers and devices
 - c. HVAC
 - i. Domestic HW heater(s) controls.
 - ii. All pneumatic and electric control valves, including air compressors.
 - iii. The BMS system should have UPS and backup standby power.
 - iv. IS&T equipment rooms and corresponding a/c units.
 - v. A/C unit for High Voltage room.

Generator sets shall meet the requirements of Massachusetts Electrical Code, NFPA 110 and NFPA 99 (where applicable).

Generator sets shall be rated continuous standby.

On application of any load up to the rated load, the instantaneous voltage dip shall not exceed 20% and recover to + or -2% of rated voltage within one second. Except fire pump 15% dip max per NFPA 20.

The generator shall be capable of sustaining at least 250% of rated current for at least 10 seconds under 3 phase symmetrical short circuit.

The voltage regulator shall be isolated from the load to prevent tracking SCR loads.

The engine shall be furnished with the following accessories:

1. Full flow, bypass spin on oil filters.
2. Oil drain valve and extension.
3. Dry type replaceable air cleaner element and restriction indicator.
4. Spin on fuel filters and strainers and a manual fuel primer pump.
5. Racor fuel strainer/water separators installed in the fuel supply line before engine fuel pump.
6. Cooling system filled with manufacturer recommended percentage of antifreeze and distilled water and coolant additive.
7. Tank type, circulating jacket water heaters to maintain engine at a constant 90°F to 120°F with oil pressure disconnect switches, ball valves on inlets and outlets and steel braided reinforced hoses with threaded connectors.
8. Manifold, turbo and flex insulation blankets.
9. 8D style lead-acid, non-maintenance free batteries with automotive posts sufficient to provide two complete sets of three crank/rest cycles of 15 seconds, 75 seconds total, each at 40°F with at least two year life cycle.
10. Battery conductor total resistance not exceeding .002 ohms including negative and positive leads.
11. A free standing battery rack.
12. Isochronous electronic speed control.
13. 78 ampere minimum battery charging alternator with solid-state voltage regulation.
14. One spare set of hoses, filters, belts, fuses, thermostats and gaskets
15. Two complete Overhaul Literature Kits.
16. Vibration isolators for field installation.
17. A float battery charger shall be provided capable of returning the batteries if fully discharged to 100% of their ampere-hour rating within 24 hours. The charger should have the following features: crank disconnect relay, manual or automatic equalize timer, adjustable charger settings, AC line compensation, automatic overload protection, fused DC output, fuse or breaker protected AC input, automatic DC regulation, and surge suppressor. It shall have a DC ammeter, DC voltmeter, low voltage alarm, high voltage alarm, power failure alarm, summary failure alarm, voltage and High DC voltage. Battery charger wiring shall be permanently connected.
18. The output circuit breaker on the Engine-Generator Set and circuit breakers in series shall be provided with auxiliary contacts to monitor circuit breaker position remotely as a supervisory alarm monitored by the local BMS system and alarmed to MIT Central Operations Center, This function shall be fully tested during on-site start-up and Commissioning.

Engine exhaust silencer shall be critical attenuation grade, aluminized steel double wall construction equal to EM Products (JCS05-1260 with #150 ASA carbon steel flange inlet and outlet connections). Low point drain with MPT threaded end and standard high temperature (1200°F) finish shall be factory furnished. Silencer shall also be furnished with 300 series 4”

diameter stainless steel braided flexible pipe connector having temperature and pressure rating to suit for connecting exhaust pipe to engine, 12 inch minimum length with #150 ASA carbon steel flange end connections.

A double wall (secondary containment) steel fuel tank (sub-base if possible) shall be factory furnished integral to each diesel generator. Capacity of the fuel tanks shall be not less than 12 hours but not more than 36 hours with the set operating at full load.

The fuel tank shall be equipped with a removable plate with gasket for inspection and periodic maintenance with a minimum of the following fittings: engine fuel supply, engine fuel return, vent, emergency vent, fuel inlet and fuel drain. A fuel level gauge and low fuel level alarm shall be factory furnished. Piping shall be entirely black iron. Pipe sealant shall be recommended for fuel oil systems and not Teflon based. Indicating type valves shall be installed on both the supply and return lines prior to the flexible lines to the engine. A battery powered normally closed electric fuel solenoid valve and a check valve shall be factory provided on the engine supply line. Manual bypasses shall be installed for all fuel solenoid valves.

Provide fuel filter. Fuel filter shall be removable, full flow bypass spin-on, cartridge type with head piece having provisions for piping connections. The filtering media shall surround a perforated steel center tube backed by a coiled steel support spring to seal the gasketed end face of the throwaway filter element against the head piece.

Provide 50% load bank.

There should be controls to allow for disengaging the load bank during when the automatic transfer switches change status from normal power to emergency power or standby power during normal power loss.

Submittal shall include prototype test certification and specification sheets showing all standard and optional accessories to be supplied, schematic wiring diagrams, dimension drawings, and interconnection diagrams identifying, by terminal number, each required interconnection between the generator set, the transfer switch, and the remote annunciation panel. Also provided are the following drawings and instructions:

1. Bill of material and catalog cuts on each separate piece of equipment.
2. Engine generator setting plan.
3. Wiring schematics for engine control.
4. Generator control panel arrangement and wiring schematics.
5. Lubricating oil specifications.
6. Gauge board arrangement.
7. Remote alarm annunciator arrangement and wiring schematics.

The manufacturer shall warrant the emergency generator system for 2 years or 2,000 hours, whichever occurs first, from the date of the site start-up. The local manufacturers' representative shall provide the first complete annual service per the written maintenance recommendations for the unit at no additional charge in the twelfth month following the date of the startup. Facilities maintenance staff shall be present during the service.

Factory Witness Tests:

1. Provide standard factory tests in accordance with NEMA standards and NFPA standard 110. Check and set all instruments and safety devices. Provide following tests:
 - a. Generator set test under rated load and power factor for 8 hours for performance and proper functioning of control and interacting circuits.
 - b. Testing at unity power factor only (resistance banks only) is not acceptable, since KW output is affected by the higher generator efficiency at unity power factor, and the KVAR for motor starting and regulation is not able to be correlated between unity and rated power factor.
 - c. Fuel Consumption: The Owner shall be notified at least 4 weeks in advance of these tests and shall have the option of witnessing these tests owner cost for air travel, hotel, and meals shall be included in specification. Certified copies of these test results shall be forwarded to the Owner for review.

Site Tests:

1. An installation check, start-up and building load test shall be performed by the manufacturer's local representative in precise accordance with the acceptance testing procedure outlined in NFPA 110 para. 5-13. Facilities maintenance staff shall be notified of the time and date of the site test and shall be present. The tests shall include:
 - a. Fuel, lubricating oil and antifreeze shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected.
 - b. Field leveling of generator skid shall be done prior to acceptance testing.
 - c. Accessories that normally function while the set is standing by shall be tested prior to cranking the engine, including block heaters, battery charger, generator strip heaters, remote annunciation, etc.
 - d. Check start-up under test mode for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and phase rotation.
 - e. Test automatic start-up by means of simulated power outage for remote-automatic starting, transfer of the load and automatic shutdown. Prior to this test, all transfer switch timers shall be adjusted for proper system coordination. Engine coolant temperature, air temperature, oil pressure and battery charge level along with

generator kilowatts, voltage, amperes and frequency shall be monitored at 20 minute intervals during the eight hour test. An external load bank shall be connected to the system if sufficient building load is unavailable to load the generator to the nameplate kW rating.

- f. Test all alarm shutdown circuits by simulating fault or failure conditions.

Provide sound attenuated walk-in enclosure. The enclosure shall be manufactured by Pritchard Brown or Robinson. The enclosure attenuation shall be 25 db at 6 feet minimum.

Automatic transfer switches shall be provided with isolation/bypass switches and shall be manufactured by Russelectric.

In engine/generator rooms, battery-pack wall emergency lighting units shall be provided with lighting fixtures directed at the automatic transfer switch and at the generator control panel.

Dampers and louvers shall fail open. Gravity type louvers shall not be used. The manufacturers recommended maximum static air inlet and outlet pressures shall not be exceeded. Ventilation shall be sufficient to maintain an engine room temperature of not more than 110 deg. F on a 95 deg. F ambient day when measured at any point at least 18 inches from the engine when operating at a sustained 100% load.

The room floor shall be coated with an industrial floor sealant and the walls sealed and painted.

There shall be 30 foot-candles of lighting to all sides of the generator when measured at the floor level.

Heating shall be provided to maintain the generator room at a minimum of 50 deg F. Provide low-temperature alarm set to alarm at below 40 deg F.

An electrical distribution panel containing all of the circuit breakers for all electrical equipment in the generator room (include battery charger, block heaters and lighting) shall be located in or adjacent to the generator room.

A freestanding or wall mounted cabinet shall be provided in the room containing spare parts, service equipment and operation manuals.

A minimum of two 120VAC electrical outlets connected to the emergency power system shall be installed within the generator room.

3.9 Automatic Transfer Switches

Automatic transfer switches shall be provided with isolation/bypass switches where critical loads are served, otherwise, non-bypass is acceptable. Contacts shall be provided for transfer switch status:

1. Normal Power Source/Source 1
2. Emergency/Standby Power Source/Source 2

The number of poles shall be coordinated with the standby power source.

Enclosures shall be fabricated from 12 gauge steel.

3.10 Distribution Panelboards

Construction of distribution panelboards shall be as follows:

1. Provide door in door.
2. Breakers shall be bolt-in except Square D breakers shall be plug-in.
3. Main breaker shall be provided without ground fault
4. All panels shall be three phase 4-wire, with copper bus and copper neutral and ground bar.

Distribution panelboards shall be located in dedicated rooms and closets.

In laboratories and critical applications, feeders shall be limited to one panel. For other locations, a maximum of two panels is acceptable.

Provide with Square D PM 5563 meter integral with communication card to distribution panel.

Provide TVSS/SPD integral to the panel. Designers shall account for the circuit breaker required for the TVSS/SPD.

3.11 Power and Lighting Panelboards

Construction of power and lighting panelboards shall be as follows:

1. Provide door-in-door type construction.
2. Buses shall be copper including 3 phases, neutral and ground bar.
3. Every panel is to have a main breaker.
4. A separate ground bus shall be provided.
5. A neutral terminal strip shall be provided on each side of the panel
6. Power panels shall have 200% neutrals.
7. Double tub panel construction is acceptable.
8. Panels shall be 42 pole or 84 pole capacity.
9. As a minimum 20% spare breakers are to be provided.
10. In general, breakers shall not be less than 20 amperes.
11. Breakers shall be bolt-on type. For circuit breakers that are not bolt-in, the spare circuit breakers shall be removed, replaced with covers, and provided to R&M to prevent theft.

12. Minibreakers are not allowed.
13. Single pole breakers with handle ties or bails shall not be used in lieu of multipole breakers.

Panelboards are to be located in dedicated rooms and closets. Provide additional space on walls for at least one future panel.

Recessed panels are to have two spare two-inch conduits with pull strings run from the panel to accessible ceiling for future use by MIT. Spare conduits shall terminate in a pull can minimum 6 inch high by 30 inch wide by 30 inch deep.

In new installations there shall be separate power panels and lighting panels.

Neutrals shall not be shared. Each single phase circuit is to have its own neutral.

The feeder cable to a 200% neutral panel shall have a 200% neutral. Transformers – 600 Volts and below.

3.12 Transformers

Windings on transformers shall be copper.

No oil-filled transformers.

Insulation system shall be 220C class. Maximum core temperature rise shall be 80C.

3.13 Motors

Coordinate with mechanical engineer to provide high efficiency inverter duty motors appropriate for use and location with consideration of utilization factors as approved by MIT.

Motors driven by VFDs shall be equipped with motor shaft grounding rings at both ends.

3.14 Variable Frequency Drives

Variable frequency drives shall have the following features:

1. Provide MTE matrix harmonic filter with 6 pulse variable frequency drives, or AC to AC matrix drive technology.
2. Maintenance bypass if required by the mechanical engineer.
3. No limitation on distance between the drive and the motor. Additionally, the motor to be used with the drive shall be an inverter duty motor, not a special drive motor.

3% load reactor for motors more than about 150 ft away. If more than 600 ft away, provide a dV/dt filter and more than 1000 ft I provide a sinewave filter.

The drive enclosure is to be NEMA 12, unless the space is determined by Facilities Engineering Group, in writing, to be clean enough to allow for a lesser rating.

All drives shall have a lockable disconnect with gasket.

Door-in-door construction with separate incoming power lugs and connections from terminal strips and relays, or, if door-in-door is not available, side car/hip-box construction.

3.15 Enclosed Safety Switches

Enclosed Safety Switches shall be Heavy Duty type with copper ground stud and shall not have pull type fused or non-fused disconnects. All enclosed safety switches shall be:

- NEMA Type 1 for indoors.
- NEMA 4X - Stainless steel for outdoors and all wet and/or corrosive environments

Coordinate with all trades to ensure ALL equipment shall be provided with permanent lockable disconnecting means in sight of the equipment INCLUDING motors, fan coil units, and other heating cooling, and refrigeration equipment.

3.16 Raceways

3/4 inch minimum conduits are required.

EMT shall be provided with steel fittings or Rigid Steel Conduit with threaded fittings for interior. Die-cast fittings are not acceptable.

Outdoor circuits and feeders shall be installed in Rigid Steel Conduit with threaded fittings.

NEMA 4X shall be provided for outdoor pull boxes and electrical equipment.

No conduit is to be embedded in basement floor slabs.

All surface raceway systems shall be manufactured by Wiremold, Carlon or Hubbell. The use of Wiremold ISO Duct Surface Raceway is prohibited. In general, Wiremold 3000, 4000 and 6000 is preferred (Hubbell and Carlon equivalent are acceptable). Non-metallic surface raceway may be used in special applications.

In laboratories, conduits shall be used between the panelboards and the surface mounted raceways.

Underground branch circuit raceways are to be schedule 40 PVC. Concrete encase with minimum of 3 inches of cover all around. Direct burial of conductors is not allowed.

MC cable is acceptable only for concealed spaces, above ceilings, fishing within walls, and for final connections where not subject to physical damage.

Access shall be provided by the construction team for all junction boxes, pull boxes and splices boxes or where wiring needs to be maintained.

3.17 Receptacles and Switches

For requirements for branch circuits, see Power Panelboards and Lighting Panelboards.

For requirements for lighting fixture switching, see Lighting.

Devices are to be specification grade.

Devices shall be rated 20 amperes.

Device plates are to be brushed stainless steel.

All switches shall be rated for 277 volt rated.

Receptacle plans shall be reviewed with the end user and MIT project manager to insure proper coverage for the areas being constructed.

There shall be a maximum of four (4) receptacles per single-phase power circuit in laboratories and high load intensity areas, (6) receptacles in classroom applications, and (8) receptacles in low load intensity areas.

Receptacles located in hallways and corridors shall be on their own branch circuit and shall not be powered from room branch circuits.

Rooftop receptacles shall be on dedicated branch circuits and not be powered from room branch circuits. Each rooftop receptacle shall be a GFI receptacle and weatherproof with in-use cast covers (plastic not acceptable).

Receptacles shall be provided on roofs with weatherproof cast in-use covers with maximum spacing of 40 feet or as required by Massachusetts Electric Code.

Receptacle plans shall be reviewed with the end user and MIT project manager to insure proper coverage for the areas being constructed.

Each electrical closet shall be provide with (1) receptacle on emergency power where emergency panels are present, optional standby where optional standby is present, otherwise normal power standby is acceptable.

3.18 600 Volt Cable

All cables shall have copper conductors.

All conductors are to be stranded. Solid conductors shall not be used.

THHN/THWN conductors shall be provided. Insulation to be 90° C rated with connectors sized for 75° C ampacity use (90° C ampacity rating of a conductor is not to be used).

XHHW and RHW cable shall be used for outdoor underground lighting and power installations.

Minimum conductor size to be #12 AWG.

MI cable shall be used for all emergency and legally required standby loads.

Splices are permitted only upon the written acceptance of an electrical representative in the Facilities Engineering Group at MIT. Factors in this decision shall include the condition of the cable, installation, critical nature of the system, accessibility to the potential splice, and the level of resiliency at the splice location.

MC cable with overall steel armor is acceptable only for concealed spaces, above ceilings, fishing within walls, and for final connections where not subject to physical damage.

3.19 Metering

All new building construction or renovation projects require provisions for the installation of meters and field devices necessary for real-time remote collection of utility data. Direct access to meters for calibration is required.

Solid state micro-processor based Electric Meter shall be installed on unit substation main breaker. The meter shall have an RS232 communication port and a RS485 communication port with OPEN Modbus protocol. If new switchgear is being installed, the meter installed in front of the main breaker shall be revenue grade. All breakers in the switchgear shall have Modbus communications included and factory wired.

The MEP design engineering team for the project must prepare a single line metering diagram depicting in detail all equipment, conduit, wiring, (power and network communication) junction boxes, network connections and any other devices necessary for a complete metering system to support the scope of the project. This drawing must clearly define and depict each individual trade's responsibility and point of connection. The clear assignment of responsibility by trade is critical to proper execution of the metering scope. MIT will collaborate with the MEP team to assist in the development of this diagram to suit the required scope within the arrangement of the building. The diagram must depict the actual path of wiring between devices including the room numbers.

Electric Utility meters should be tied into a UPS . The UPS provide 12 hours of backup after a power loss.

3.20 Lightning Protection

The electrical engineer is required to run the lightning risk assessment for the building and provide protection for the building, structures, and equipment as recommended, unless otherwise directed by MIT Department of Facilities.

4. LIGHTING STANDARDS

4.1 Lighting General Requirements

As a minimum, all buildings must be designed to The Illuminating Engineering Society of North America (IESNA) lighting level design guidelines outlined in the IESNA Lighting Handbook 10th Edition.

“For additional information on specific requirements for lecture halls and classrooms see Thematic Folder [“Classroom Lecture Hall Renovation New Construction Guidelines”](#)”

MIT lighting level requirements are:

- Classroom – 30fc maximum avg horizontal on working surface
- Office – 30fc maximum avg horizontal on working surface
- Laboratory – 50fc maximum avg horizontal on working surface
- Corridors – 5-10fc maximum avg horizontal at floor
- Lobbies – 10fc maximum avg horizontal at floor
- Stairwells – 10fc maximum avg horizontal at floor
- Exterior Pathway and Parking – 1fc avg horizontal at grade level

All interior lighting shall have a minimum Color Rendering Index (CRI) of 82.

All interior lighting shall be 3500K color and all exterior lighting shall be 3000K color. 3000K is also accepted where preferred for user comfort.

High bay light fixtures shall have a twist-lock plug and cord for easy removal to perform maintenance. The design shall include twist-lock receptacles to connect the lighting. Emergency battery shall be provided for emergency lighting, if emergency power is not available from a generator.

Provide emergency lighting in electrical switchgear rooms, engine-generator rooms, electrical, mechanical, tel\data closets, office and laboratory suites, and toilet rooms.

For lighting connected load power densities, MIT's indoor lighting power density goal is 0.7 w/sf, maximum.

The design team shall prepare and present to MIT for review photometric plots for all spaces no later than the design development phase. The team shall review for compliance to standards prior to submitting to MIT for review.

LED lighting fixture manufacturers shall provide MIT with at least a 5 year warranty or greater, a minimum (CRI of 80); and a color temperature of 3500K. Exterior LED color temperature shall be 3000K.

Drivers shall be Lutron Hi-Lume, where available from lighting manufacturer.

Light fixtures shall be placed where they will be able to be maintained without special equipment to access them.

Provide Electric Battery Units in the tel/data rooms and closets.

4.2 Lighting Controls

Auto-Off, Manual-On vacancy sensors shall be utilized in all non-corridor, non-circulation, non-toilet room, non-laboratory spaces. Sensors shall be set to 15 minute timeouts. These are to be coupled with momentary wall mounted lighting switches. These spaces shall also be provided with dimming controls.

Auto-Off, Auto-On occupancy sensors shall be utilized in laboratories unless the laboratory use requires the lighting to be turned off while the room is occupied in which case Auto-Off, Manual-On vacancy sensors shall be used. Sensors shall be set to 30 minute timeouts. These are to be coupled with momentary wall mounted lighting switches.

Auto-Off, Auto-On occupancy sensors shall be used in all open office areas, corridors, stairwells, lobbies, circulation spaces, and toilet rooms to control Normal power lighting fixtures in these spaces. Sensors shall be set to 15 minute timeouts. Stairwell lighting fixtures may use integral motion sensors and must dim as opposed to turning off. Emergency power lighting fixtures in all corridors, lobbies, circulation spaces, and toilet rooms shall remain uncontrolled.

Daylight sensors shall be installed to provide daylight dimming in all applicable areas. Lighting fixtures coupled with daylight sensors must dim up and down as opposed to turning off and on.

All sensors shall be either Lutron wireless ceiling/wall mounted passive infrared and ultrasonic sensors, Lutron wired ceiling/wall mounted dual technology passive infrared and microphonic sensors, or Sensor Switch ceiling/wall mounted dual technology passive infrared and microphonic sensors. Lutron is the preferred manufacturer of these sensors.

All local room level personal dimming controls must be Lutron or Sensor Switch. Lutron is the preferred manufacturer of these local room level personal dimming controls. If stand alone

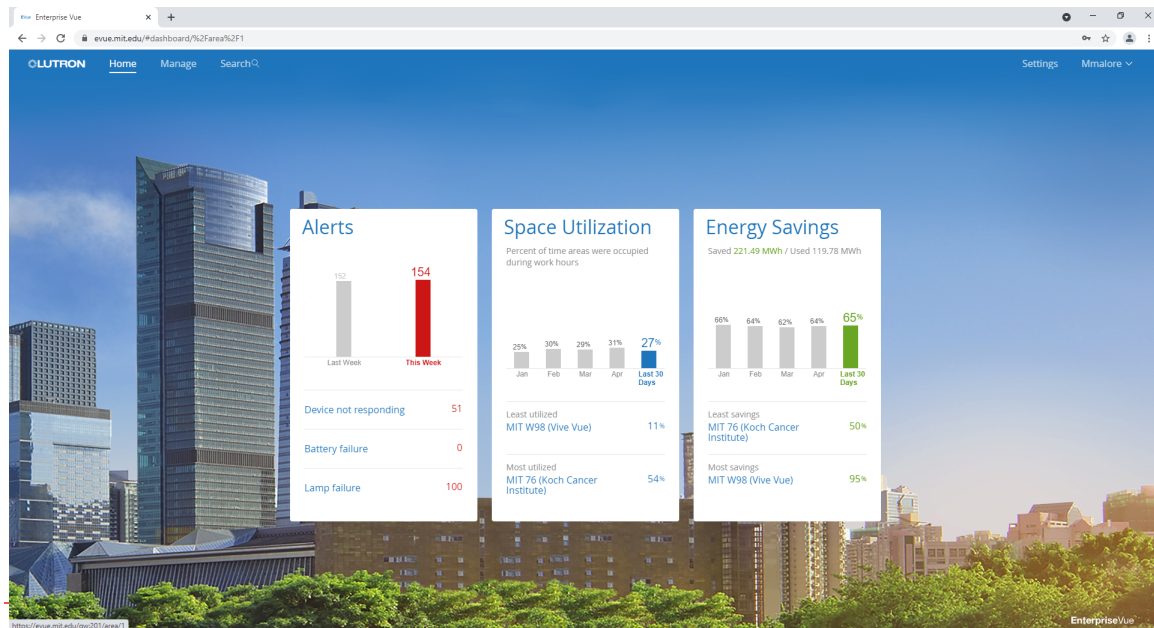
controls are used in these spaces, the product being used shall have the ability to live under a Enterprise lighting control solution as needed in the future.

All network lighting controls systems must be Lutron or Crestron. Lutron is the preferred manufacturer of these network lighting control systems. When a Lutron network lighting control system is specified it shall be tied into the existing Lutron Enterprise control infrastructure. If there is an existing Lutron network lighting control system in a project building it is preferred to build upon the existing system in that building.

All Network Lighting Control systems shall be specified with a conceptual one-line during the design development process showing all server, network and system devices.

All network lighting control systems shall offer the following features:

- BTL certified BacNet integration for monitoring via the BMS
- Floor Plan Navigation with Monitoring and Reporting
- Astronomic Timeclock capabilities for all controlled loads
- Load Shed capabilities on a room by room basis accessible through the GUI or BMS via Bacnet
- System diagnostics and device failure alerts
- Current and historical lighting energy consumption data
- Current and historical space utilization data
- Ability to change occupied/unoccupied settings based on time of day
- AV integration capabilities via API, RS232, Telnet and/or Contact Closures



Astronomical timer switch control shall be used to control exterior lighting. Provide a minimum 3 year battery to maintain program memory during a planned or unplanned power outage. The Astronomical timer switches shall be Intermatic ET800 series. When a network lighting control system is specified exterior lighting shall be controlled by that system.

The manufacturer of any specified lighting control system shall offer the following services to ensure a seamless turnover. Project shall dictact required services

- Onsite system startup by manufacturer or certified programmer.
- Afterhours onsite system startup by manufacturer or certified programmer.
- Onsite scene and level tuning.
- Onsite performance-verification walkthrough.
- System performance-verification documentation.
- Customer-site solution training.
- System optimization service.
- Onsite system network and integration service.

All alternative lighting control strategies must be approved by MIT Systems Engineering Group (FEG) in writing. By completion of design development design stage.

The design development drawings shall provide a narrative or sequence of operation for each space. The narrative shall require the electrical contractor to install, setup, test and adjust the controls to meet the performance intended.

4.3 Lighting Fixtures

For Main Group Building Lighting, refer to Thematic Folder T09, Par. 2.1 - Building Products.

Contact OCP for campus standard exterior lighting fixtures. Fixture selection depends on campus location and use.

All lighting fixtures must be manufactured by an approved major manufacturer and/or be represented by an approved local lighting manufacturer product representative. Approved lighting manufacturer product representative companies are Omnilite, Reflex Lighting, Boston Light Source, Apex Lighting Solutions and Illuminate.

All LED tubes shall be Type C, LED tubes and remote LED driver. Type A and Type B LED tubes, LED tubes with an integral driver and LED tubes powered by fluorescent ballasts, are not allowed.

All exterior wall pack lighting fixtures must be full cut-off wall packs. Integral motion sensors which dim the lighting fixture to 50% power consumption are acceptable. Sensors shall be set to 15 minute timeouts. Approved fixture for this use are Philips Gardco or Bega equivalent.

Preferred lighting fixtures/technologies are:

- Finelite HPR recessed/surface mounted 1'x4', 2'x2', and 2'x4' lighting fixtures.
- Lutron LED drivers.
- Osram Sylvania fluorescent lamp and ballast combinations.
- Philips or Lunera LED Type C tube and remote driver combinations.

Refer to Appendix C List of Products for additional information.

All alternative lighting fixtures/technologies must be approved by MIT Systems Engineering Group (FEG) in writing.

4.4 Exit Signs

All new interior exit signs shall be Sigtex CRS series, LED edge lit exit sign (or equal). Provide all exit signs with mirrored rack or core. Green exit signs shall be provided for new spaces. Red may be used if the space has existing to remain red exit signs.

For new exit signs in industrial or back of house spaces, provide the McPhilben Chloride Series, LED edge lit exit sign.

APPENDIX A: LIST OF PRODUCTS

Product Type	MIT Requirements
1. Conduit raceways	No preference
2. Surface mounted raceways	Carlson, Hubbell and Wiremold
3. Medium voltage cable	Okonite and Kerite
4. Low voltage cable	Southwire, Rome
5. Enclosed Safety Switches	GE/ABB, Eaton, and Square-D
6. Transformers	GE/ABB, Eaton, GE, and Square-D
7. Load breaker primary loop switches	G & W Electric Co.
8. Low voltage unit substation	ABB, Eaton, GE, and Square-D
9. Motor control centers	Allen-Bradley, Eaton, GE, and Square-D
10. Motor starters	Allen-Bradley, EATON, GE and Square-D
11. Motors	Baldor, Emerson, GE, Marathon
12. Distribution panels	Square D I-line, Eaton Pow-R-Line 5P, GE equal
13. Lighting panels	Eaton, GE, and Square-D
14. Engine generators	Caterpillar and Cummins
15. Enclosed Safety Switches	Eaton, GE, and Square-D
16. Automatic transfer switches	Russelectric, ASCO, or Eaton
17. Automatic fire pump transfer switches	Russelectric
18. Automatic transfer switches	Russelectric
19. Manholes and handholes	No preference
20. Metering	Eaton, GE, and Square-D

21. Wiring devices	Hubbell, Arrow-Hart, Leviton, Pass & Seymour
22. Motion and daylight sensors	Lutron, Sensor Switch, Leviton, Greengate, Wattstopper
23. Local lighting controls	Lutron, Sensor Switch, Leviton, Greengate, Wattstopper, Hubbell
24. Network lighting controls	Lutron and Crestron
25. Exit signs	Sigtex (or equal)
26. Fuses	Bussman, Ferraz Shawmut, and Mersen
27. Disconnect switches	Eaton, GE, and Square-D
28. Busways	Eaton, GE, and Square-D
29. Power factor correction	No preference
30. Grounding	Cadweld and Burndy
31. Transient Voltage Surge Protection	Eaton, GE, and Square-D
32. Lightning Protection	No preference
33. Variable Frequency Drives	Allen-Bradley, Emerson, ABB, Eaton, Schneider, Yaskawa
34. Uninterruptible Power Supplies (UPS)	Liebert and Mitsubishi, APC, Emerson, Powerware
35. Heat Tracing systems	Raychem and Nelson
36. Cathodic Protection systems	No preference
37. Leak Detection systems	No preference
38. Fire Stops	No preference

APPENDIX B: POWER SYSTEM STUDY - SAMPLE SPECIFICATION

POWER SYSTEM STUDY

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. A Short Circuit Study, Protective Device Evaluation Study, and Protective Device Coordination study shall be performed, stamped and signed by a Professional Engineer registered in the Commonwealth of Massachusetts engaged to carry out such studies by the distribution equipment manufacturer. The cost of this study shall be included in the bid of the Electrical Sub-Contractor.
- B. The studies shall be submitted to the Architect for review with the distribution equipment shop drawings and shall under no circumstance be submitted after the final release of equipment for manufacture.
- C. The studies shall include all portions of the electrical distribution system including any equipment pre-purchased by the owner and installed by the Electrical Contractor, as well as the next 13.8kV primary upstream over-current protection device and all downstream devices in the building including all normal and emergency sources of power and motor loads within the building.
- D. The Electrical Subcontractor shall be responsible for coordinating the execution of these studies in a timely manner and shall be responsible for supplying all required data in preparation for the study.
- E. The studies shall be performed with SKM Power Tools software and shall be in accordance with the latest applicable IEEE and ANSI standards.
- F. The report shall include, but not be limited to a statement of calculation methods and assumptions, the base per unit quantities selected, one-line diagrams, source impedance data, calculations, tabulations, results, conclusions and recommendations.
- G. Provide Time-current curves graphically indicating proposed coordination for the system. With each curve, provide a detailed description of particular devices

identifying manufacturer, type, function, and time-current characteristics.
Provide associated partial one-line diagram and tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings.

- H. Include all adjustable settings for ground fault and recommendations for settings and delays for these devices.
- I. Include phase and ground coordination of the engine-generator devices. Show the generator decrement curve and damage curve along with the operating characteristics of the protective devices. Obtain the required information from the generator manufacturer and include the generator actual impedance values, time constants, and current boost data in the study. Do not use typical values for the generator.
- J. The Electrical Sub-Contractor shall make all the final adjustments to overcurrent devices as recommended in the study. The Electrical Sub-Contractor shall prepare and install all Arc Flash labels in accordance with the results of the Power System Study.

1.02 STUDY REPORT

- A. The results of the power study report shall be summarized in a final report. Six (6) bound copies of the final report shall be submitted to the Architect and MIT Senior Electrical Engineer for review.
- B. The report shall contain the following sections and documents:
 - 1. Descriptions, purpose, basis and scope of the study.
 - 2. Tabulations of circuit breakers, fuses and other protective device ratings versus calculated short circuit duties, and commentary regarding same.
 - 3. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip settings, fuse selections, fuse selection and commentary regarding same.
 - 4. A table listing all settable /adjustable devices with the values they are set to and the date the work was completed by the Electrical Sub-Contractor.
 - 5. Fault current calculations including a definition of terms and guide for interpretation of computer printout.
 - 6. Provide (2) compact disk copies of entire SKM model file including device library, system one-line diagram, impedance diagrams, available short circuit currents, coordination curves for each section of the distribution system, arc flash

energies and boundaries at each piece of electrical equipment, and the recommended coordination settings for each piece of adjustable electrical equipment in the distribution system.

7. Provide (2) 24" x 48" copies of the entire electrical distribution system riser diagram in both SKM format as well as in the original Autocad Building Electrical System Power One-Line Diagram Format showing SKM values for available short circuit current and available Arc Flash energy at each bus within the distribution system.

PART 2 - PRODUCTS

2.01 TESTING MATERIALS

- A. Include all material, equipment and devices necessary for testing to demonstrate satisfactory performance and compliance with specifications.

PART 3 - TESTING

3.01 TESTING

- A. Before an application for final acceptance of the work will be considered, all tests deemed necessary by the Architect to show proper execution of the work shall have been performed and completed in the presence of an Architect's representative. Scheduling of all testing procedures shall be arranged to suit the convenience of the Architect. The Owner shall be notified two working minimum days prior to any acceptance testing.
- B. In particular, testing of the emergency power system shall be provided complete in accordance with all of the requirements specified in Section 5-13, "Installation Acceptance" of NFPA 110, "Standard for Emergency and Standby Power Systems."
- C. The electrical work shall include the provision of any assistance (such as removal of panelboard trims and junction and pull box covers) deemed necessary by the Architect to demonstrate compliance with the requirements of the drawings and specifications.
- D. Where electricity utilizing equipment, supplied separate from the electric work, is energized, controlled or otherwise made operative by electric work wiring systems, the testing to provide the proper functional performance of such wiring systems shall be conducted by the trade responsible for the equipment. The electrical work shall, however, include cooperation in such testing and the

making available of any necessary electrical testing equipment. Also, testing shall be included in the electric work to show the proper functioning of lighting fixtures regardless of who furnishes them.

- E. Electrical Acceptance Tests and Inspections: Furnish the Architect and the Owner with certificates or reports of testing and inspection of electrical systems by an independent testing company. Certificates or reports shall indicate approval of authority having jurisdiction and conformance to specifications.

END OF DOCUMENT