

# Electrical Basis of Design Standards and Guidelines

The following design Standards and guidelines shall apply to all systems within the electrical engineering discipline. The purpose is to provide uniformity of design based on these established standards and guidelines.

## **E.1. General Building Guidelines and Design Considerations**

### **E.1.1. Calculations**

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

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

### **E.1.2. Design**

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

### **E.1.3. Design Analysis Narrative**

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

### **E.1.4 Maintenance and Operational Manuals**

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

### **E.1.5 Panel Schedules**

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

- Panel name
- Number and size of spare breakers
- Number of bused spaces and the maximum ampere ratings
- Total number of breaker positions in the panel

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

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

The WSU is a progressive and dynamic educational and research institution where state-of-the-art medical research and high standards of education is the norm. To support state-of-the-art teaching, and research, the facilities must also be state-of-the-art. Therefore, it is the intent to build and maintain the electrical systems and facilities in accordance with the latest standards. It has been WSU's experience that the renovation and rehabilitation of existing facilities do not always lend themselves to incorporating the "latest" standards of the industry. Some of the existing electrical systems are outdated or inadequate for the new load. Often the planned function is incompatible with the original criteria for the building. The A/E shall be alerted to this type of situation and make an evaluation early in the design stage to determine the implementation feasibility of the latest standards. The A/E shall document such findings, provide recommendations, and report them to the Project Officer for a decision on how to proceed. The A/E design firm shall use and comply with, as a minimum, the latest issue of the following design and safety guidelines. In addition, the A/E shall use other safety guidelines received from WSU Project Officer or as required by the program. The A/E shall utilize the latest versions of guidelines available at the time the project proceeds with schematic design. The reference codes, regulations, and recommended practices include but are not limited to the latest version following:

- Association of Edison Illuminating Companies (AEIC)
- American Hospital Association (AHA), Management and Compliance Series, *Electrical Building Code*
- Electronic Industries Association (EIA) • International Cable Engineers Association (ICEA)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE), color books
- Illuminating Engineering Society of North America (IESNA), *Lighting Handbook*
- Lightning Protection Institute, LPI 175 Standard of Practice
- National Electrical Code (NEC), National Fire Protection Association NFPA Standard 70
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC) IEEE C2
- International Electrical Testing Association (NETA), *Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems*
- NFPA, National Fire Codes (NFC)
- Telecommunications Industries Association (TIA)
- Uniform Federal Accessibility Standards (UFAS)
- Underwriters Laboratories (UL)

## **E.2. Energy Conservation**

### **E.2.1. Electronic Ballasts**

Electronic ballasts shall be used in all fluorescent lighting fixtures. See the Lighting section for ballast specifications.

### **E.2.2 Fluorescent Lamps**

Fluorescent lighting fixtures 24 in x 24 in, 24 in x 48 in shall use T8 (1 in diameter) lamps. The ballast/lamp combination shall have an efficacy in excess of 90 lumens per watt (LPW).

### **E.2.3 Programmable Lighting Control (PLC)**

The use of relays to control lighting circuits or sub circuits with lighting contactors is encouraged from an energy conservation standpoint. The system must be flexible and easy to use. Corridors are a good application for PLC.

### **E.2.4. Occupancy Sensors**

Occupancy sensors work well in conference rooms, bathrooms, and single-person offices. An ultrasonic-type sensors shall be utilized in enclosed rooms such as bathrooms and conference rooms. A passive infrared-type sensors shall be utilized in single offices. The ceiling-mounted, ultrasonic and switch replacement, passive infrared units shall be specified depending on the room configuration. Dual technology should be used in lieu of a single technology for all installations unless this would lead to miss-application of a technology. The designer shall check with the manufacturer for recommendations. Where fluorescent lighting fixtures are controlled by occupancy sensors, they shall have program rapid-start electronic ballasts.

### **E.2.5. Lighting Control**

Localized switching shall be provided in lieu of large-area switching. Labs shall be switched in 12 foot width groups within multi-modules.

### **E.2.6. Multilevel Switching**

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

### **E2.8. Day Lighting**

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

### **E.2.9. Exit Signs**

Light emitting diode type exit signs shall be used at WSU. Exit Signs shall have a minimum 10 year warranty. Fixtures shall either be edge glow style in finished spaces and white polycarbonate in unfinished spaces. Both shall have red letters.

### **E.2.10. High-Efficiency Motors**

The use of high-efficiency motors shall be specified for all applications.

### **E.2.11. Metering**

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

### **E.3. Economic Analysis**

An economic analysis shall be performed when a clear choice is not apparent between two or more possibilities. When there are two choices, the simple payback method can be used. Three or more choices requires the present-worth analysis method.

### **E.4. Normal Power**

All metering shall be Square D to interface with existing Square D Power Server equipment. Every new unit substation shall have a Square D Powerlogic 3350 or greater metering package installed.

#### **E.4.1. New Service Connection**

WSU will determine the most appropriate location for a service connection to the primary voltage (12.477 kV) system on campus. The service connection may be made by tapping to an existing feeder in a manhole or by adding a new feeder from the nearest 15 kV loop switch.

#### **E.4.2. Standard Cable Size and Type**

WSU has standardized on Ethylene Propylene Rubber (EPR) insulated cable and on 500 thousand circular mils (KCMIL) as the preferred size for the 15 kV cable. The system voltage is a nominal 12.5 kV. The load carrying capability of 500 KCMIL cable is much higher, at 12.5 kV, than is needed for most of the loads on WSU campus. The 500 KCMIL size has been chosen as a standard size to simplify fault calculations and to reduce the amount of stock cable for replacement purposes. The large size allows for future expansion without replacing feeders. The EPR cable shall be 15 kV single copper conductor, shielded at 105 degrees C and rated with a 133% insulation level. The strand screen shall be extruded semi-conducting EPR meeting or exceeding the electrical and physical requirements of ICEA S-68-516, AEIC CS6, and UL 1072. The shield shall be 5 mil thick bare copper tape helically applied with a 12-1/2% overlap. The jacket shall be a polyvinyl chloride (PVC) jacket. The cable shall be UL listed as Type MV-105 in accordance with UL 1072. Each feeder shall consist of three single-conductor cables, plus a ground wire as described hereinafter, or a three-conductor cable with an integral ground. Where EPR cable is installed, it shall have a copper ground conductor installed with the phase conductors. The ground conductor shall be No. 1/0 AWG minimum in accordance with NEC Article 250-51 and Table 250-94. All splices shall be custom made at each location by an experienced cable splicer using customized splicing kits from a reputable cable manufacturer. All splices shall be started and carried through to completion without interruption, usually taking about 8 hours.

#### **E.4.3. Distribution Duct System**

WSU has two underground duct and manhole systems; one is for electrical power cables and one is for communication circuits. The electrical power ducts contain only high-voltage feeders, rated 15 kV for use on WSU nominal 12.5 kV system. The area surrounding manholes in grass areas shall be re-graded to drain away from the manhole cover. Manhole covers shall be 0.5 in above finish grade. Manholes shall be provided with a sump approximately 12 in x 12 in x 6 in deep. Preferable manhole locations shall be in grass areas first, sidewalks second, and in the street last. Manholes shall not be located in parking spaces. Where ducts are sloped from a high to a low manhole, they shall be sealed at the high end only to allow condensation to drain. Cables in manholes shall be labeled with embossed brass cable tags and brass chains. Manholes shall be provided with two manhole covers, one for forced air and materials entry and the other for worker access. The standard manhole frame and cover shall be 39.5 in diameter

(36 in inside diameter). Manhole covers shall be labeled ELECTRIC for power and COMMUNICATIONS for communications. The cover shall have a small, flat area for labeling with the manhole number by a welded bead. An embossed brass tag with the manhole number shall be permanently mounted inside the chimney and legible from outside the manhole with the cover removed.

#### **E.4.4. Elevation Considerations**

All multiple duct runs between manholes shall be minimum 4 in. inside diameter PVC Schedule 40 ducts with a concrete encasement. The encasement has steel reinforcement in a plane just below the lowest row of ducts where the duct run spans disturbed earth, where it enters manholes and buildings (out to 5 ft), and where it crosses under heavily traveled roadways. The spacing between ducts is 3in. in all directions. The ducts shall be 30 in. minimum clear below grade or top of roadway. Duct runs shall be sloped from the higher manhole entrance to the lower manhole entrance with no intermediate low spots that would pool moisture. If manhole entrance points are on about the same level, then there must be an arch in the duct run so that there is drainage from a high point into both manholes. If a low point is absolutely unavoidable, another manhole shall be provided at or near the low point.

#### **E.4.5. Grounding**

Each manhole shall be equipped with a 10 ft. long, 0.75 in. copper clad steel ground rod through the floor of the manhole, with all metallic components in the manhole such as racks, cable sheaths, ladder, etc. securely grounded to this rod with a #6 AWG green insulated cable.

#### **E.4.6. Maximum Length Between Manholes**

The maximum cable length between manholes for power shall be kept to less than 1000 ft. for an essentially straight run (400 ft. for communications) and reduced by 50 ft. for each bend of 45 degrees and by 100 ft. for each bend of 90 degrees. Bends shall be made with the largest radius possible. This by no means releases the engineer or the contractor from doing the necessary cable-pulling calculations to make sure the maximum tension or sidewall pressures are not exceeded.

#### **E.4.7. Spare Capacity**

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

#### **E.4.8. Calculating the Service Entrance Size**

The following load figures in voltamperes per square feet (VA/ft<sup>2</sup>) shall be used in sizing the overall building service for an office building. For load figures on laboratories, classrooms, and offices see the respective books. These figures are connected load and shall be used in the early design stages. Actual design loads shall be used in the later part of the design. The range provided is to allow for varying intensity of usage. The mechanical loads do not include chilled water generation, which may be produced in another building on the WSU campus. The engineer shall use sound judgment in applying these numbers.

<u>Load</u>	<u>VA/ft<sup>2</sup></u>
Lighting	3.2- 3.8
Receptacles	3.2- 4.8
Heating, ventilation, and air conditioning (HVAC)	5.4
Elevators	1.1
Miscellaneous	1.1
Total range	14.0-16.2

#### **E.4.9. Building Substations**

The typical building service shall consist of two unit substations one 120/208V and one 277/480V. Each transformer shall be sized for 125% of the total building load including any spare or future capacity. Building substations shall consist of a 15 kV primary HVL switch, a dry type transformer, and a secondary fusible main and distribution. The transformer manufacturer shall coordinate and be responsible for the entire unit substation (switch, transformer, and secondary main and distribution).

#### **E.4.10. Location**

The building substations shall be located indoors in a 2 hour rated electrical vault (room). The vault shall be a minimum of 30 ft long by 25 ft wide with a 6 ft wide door in the middle of the 25ft width. The room shall be a minimum of 12 ft high measured from floor to the bottom side of the floor structure above. All main vaults shall be on the basement level for easy access to the tunnel system.

#### **E.4.11. Removal Route**

The size of building transformers and the requirements for power reliability at WSU require that there be an exit route specified for these large, heavy items of electrical equipment. The designer of the building must provide for a permanent exit route to remove these large items and bring in new units. Note that the faulty unit must be removed while the other unit substation remains in place and in operation.

#### **E.4.12. Primary Switch**

The 15 kV primary switch shall be an HVL load break switch. The fusing shall be sized accordingly. The switch shall be bused to the transformer as an integral part of the unit substation.

#### **E.4.13. Transformer**

Building transformers shall have digital temperature gauges that communicate with the Powerlogic metering system. The transformer shall have five tap settings, two above and two below the 100% rating. Each tap shall represent 2-1/2% of nominal voltage. Transformer windings shall be copper and full kVA rated.

#### **E.4.14. Secondary Main Overcurrent Device of unit Substation**

The unit substation will contain a fusible switch such as a bolt-loc type as the secondary main on the load side of the transformer. This switch shall be an integral part of the unit substation.

#### **E.4.15. Secondary Distribution Sections of Unit Substation**

Low-voltage (below 600 V) switchboard is defined as a metal enclosure containing fusible switches in individual grounded metal compartments. The internal switchboard busing shall be copper and shall be insulated with PVC or other tough insulating material, except at split connections and where cable connectors are located. At these locations removable boots shall be provided for inspection of connection points. Square D Powerlogic metering shall be provided on the line side of the secondary main overcurrent device. The following minimum metering is required:

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

Spaces in switchboards shall be fully bused. Spaces shall have insulated covers over bus stabs and ready for fusible switch installation. Switchboards shall be located in electrical rooms dedicated to such use. No

pipng, ducts, or equipment foreign to the electrical equipment shall be permitted to be installed in, enter, or pass through electrical rooms in accordance with NEC requirements. Switchboards shall have the joints in the top (between sections) caulked with silicone after installation. Likewise, any conduit connections that are not inherently watertight shall be caulked. Electrical equipment that requires specialized tools for installation, maintenance, calibration, or testing shall have such tools supplied with the associated equipment and turned over to WSU at the end of the construction project. These tools can be as simple as a special screwdriver for vandal-proof lighting fixtures or the very complex test and calibration equipment needed to maintain solid-state circuit breakers. The argument that says tools are proprietary is not acceptable, and withholding the tools shall be cause for non-acceptance of the respective equipment needed to maintain solid-state circuit breakers.

#### **E.4.16. Load Segregation**

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

#### **E.4.17. Work Space**

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

- 6 ft. in front minimum (may be shared with opposite facing switchgear).
- 3 ft. in rear minimum (may use front accessible gear only then it would be 0 ft.).
- 3 ft. on the ends minimum

Renovation projects shall have at least the code minimum clearances.

#### **E.4.18. Voltage**

The standard voltages on WSU campus are:

- 12,477 V 3 phase, 3 wire Primary voltage
- 480/277 V 3 phase, 4 wire secondary voltage for lighting and mechanical loads.
- 208/120 V 3 phase, 4 wire secondary service voltage for receptacle and miscellaneous mechanical loads.

#### **E.4.19. Fire Pump**

A fire pump, if required, shall be connected to the secondary switchgear with a feeder switch. The feeder switch shall be sized to carry the fire pump locked rotor current. The mains and ties for the switchgear shall be sized to carry the maximum building demand each breaker will carry plus the fire pump locked-rotor current. The feeder shall be routed outside the building per the NEC requirements or shall have a 2 hour fire rating.

#### **E.4.21. Reliability**

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

#### **E.4.22. Testing**

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

**Table No. 1**  
**Tests Required for Electrical Equipment**

**Primary Cable**

15 kV Cable Insulation Resistance

**15 kV HVL Switch**

Visual

Contact Resistance

**Building Transformer**

Visual

AC high-potential test on primary windings and switch

Insulation Resistance test on primary and secondary windings

Turns Ratio on all tap positions

**Secondary Switchgear**

Visual and Mechanical

Insulation Resistance

High Potential

Instrument Transformers

**Power Circuit Breaker**

Visual and Mechanical

Insulation Resistance

Pickup and Time Delay Values

Operation

**Motor Control Center**

Visual and Mechanical

Insulation Resistance

Overload

Bus and Starters

**Ground Fault**

Visual and Mechanical

Neutral to Ground Resistance

Pickup and Time Delay

**Generator**

Visual and Mechanical

Insulation Resistance

Protective Relay

Phase Rotation

Load Test

Automatic Transfer

Switches

Visual and Mechanical

Contact Resistance

Insulation Resistance

Relay Settings

Timer Settings  
Operation

**E.4.23. Wire Color Coding**

Wire insulation shall be color coded. Branch-circuit conductors shall have colored insulation. Larger conductors shall be taped with the appropriate color tape for a minimum 6 in. starting from the termination. Each conductor of multi-conductor cable shall be color coded the same as single conductors. Color coding shall be as in Table No. 2 for power conductors in the given voltage systems:

**Table No. 2**

**Color Coding for Wire Insulation**

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

**E.4.24. Conduit**

Conduit shall be metallic to provide a redundant ground path. PVC or aluminum conduit is not acceptable except as noted below. PVC conduit may be used in underground applications and shall be used in concrete ductbanks. All conduits shall be clearly shown on the contract drawings. Homerun arrows with panel designation and circuit numbers are acceptable. All switch legs and circuit continuations shall be indicated on the contract drawings. Conduits shall be clearly indicated where they are to be installed exposed and where they are to be installed concealed. The couplings used on electrical metallic tubing (EMT) shall be rain tight compression type. Set screw couplings shall not be allowed. The minimum conduit size shall be 0.75 in.. Surface mounted conduit in wash down areas shall be RGS with threaded couplings. Flexible metal conduit (Greenfield) shall be used for lighting fixture connections (whips) only. Liquid-tight, flexible metal conduit shall be used for connections to equipment subject to vibration, noise transmission, or movement. Lighting fixture connections shall be made with minimum 4 ft. and maximum 6 ft. lengths of flexible metal conduit in accordance with NEC 410-67.

**CONDUIT COLOR SCHEME**

<b>SYSTEM</b>	<b>RACEWAY COLOR</b>	<b>DEVICE &amp; PLATE COLOR</b>
Fire Alarm	Red	Red
Voice/Data/video/security	Blue	N/A
Normal Power	Unpainted	N/A
Emergency/Life Safety	Orange	Red
Stand-By	White	Gray
Lighting	Black	N/A
Dedicated Grounding	Green	N/A
Wireless Way-finding	Yellow	N/A

**E.4.25. Surface Metal Raceway**

Surface metal raceway shall be metallic; plastic is not acceptable. The standard is Wiremold 4000 series. All other series must be approved by the university electrical engineer. Emergency circuits shall be wired in separate channels from normal circuits. Power and communications shall be in separate channels.

#### **E.4.26. Busway**

Busway shall have all solid copper bus. Ventilated busway shall be installed in dry locations not subject to moisture. Non ventilated busway may be installed in wet or dry locations.

#### **E.4.27 Cable Tray**

Cable tray shall be made of aluminum and of the ladder type for all power and communication cables. Cable trays shall consist of factory manufactured units that bolt together in the field. The minimum cable-tray size for communications cable shall be 12 in. x 4 in. nominal. Fabrication in the field, other than the shortening of a single straight section per each straight run to meet field conditions, will not be permitted. Corners, intersections, and tee units shall be standard manufactured units for this purpose; modification of straight sections to meet these needs will not be permitted. Where vertical space permits, and as approved by the Project Manager, tees and intersections can be in the form of two separate, straight tray sections at differing elevations; minimum spacing between these sections in the vertical direction shall be 6 in. Ventilated tray bottoms, in lieu of ladder rungs, will not be acceptable. Cable trays are to be routed near the side of the utility or pedestrian corridor wherever possible. Cable-tray locations shall be coordinated with adjacent utilities so that the tray will be accessible for adding or removing cables in the future. Routing shall also be adjusted so as not to obstruct access to other utility items that would routinely require access for maintenance or adjustment. The cable trays shall be supported directly from the building structure above and side walls wherever possible. Bridging of other utilities with a trapeze arrangement is acceptable. The spacing of the support points shall be as recommended by the cable tray manufacturer. Supporting cable tray from suspended ceiling construction shall not be permitted.

#### **E.4.28. Panelboards**

Circuit breakers shall be bolt-on type. Plug-in-type breakers are not acceptable. The breaker shall have a published ampere interrupting rating at 125/250 V DC. This latter requirement is sometimes referred to as requiring an E-Frame breaker. (A DC rating for the one-pole and two-pole breaker shall be assumed by WSU to extend to the three-pole device as well, for purposes of this requirement.) The specified minimum DC rating is 5,000 A at 125/250 V DC. Note that some manufacturers do not publish this data, as it is an expensive procedure to have UL do the necessary tests to obtain the DC rating. Breakers without the DC rating or listing are not acceptable. Every panelboard shall have a main breaker in the same enclosure, closet, or room. The main breaker can be likened to a local disconnect and must be readily accessible should the panelboard need to be deenergized in an emergency situation. Single-pole breakers shall not be ganged to form multi-pole breakers. Series rated equipment is not acceptable. The panelboard directories shall be typed and shall reference the actual room numbers for the circuits. This shall be specified as part of the Contractor's responsibility regardless of room numbers used on the drawings. The directory shall list the panelboard name and the name of panel it is fed from. New panelboards shall contain 25% spare circuit breakers. The spare breakers shall be left in the OFF position, and the panelboard directory card shall list the word SPARE for these breakers. New panelboards shall contain space for future circuits that amount to at least 25% of those required in the initial design. Panelboards shall be located in electrical rooms or closets with code-required clearances and 3 in. minimum separation. Bathrooms, labs, or other rooms requiring floor drains or plumbing in the floor shall not be located above electrical rooms or closets. No pipes, ducts, or equipment foreign to the electrical equipment shall be installed in, enter, or pass through electrical rooms or closets in accordance with NEC requirements. Branch circuits shall not be served from panelboards located in an adjacent building, area, wing, or located on a different floor. Panelboards shall be labeled with name and feeder source panel or riser source location. The nameplate shall be a phenolic laminate with engraved black letters on a white surround. Emergency panels shall be white letters on red surround. The panel name shall have 0.5 in. high letters. The words FED FROM PANEL XX OR SWGR XX shall be 0.35 in. high on a line below the panel name. Panelboards shall have a 100% neutral bus, a ground bus, and all buses shall be copper. Panels serving high harmonic load content (50% nonlinear load) shall have a 200% neutral bus. All

panelboard breaker busing (extension fingers) including spaces shall be rated for 100 A minimum. Distribution panels shall be defined as those panels serving branch circuit panelboards and other three-phase loads. Distribution panels shall be labeled DP-1, 2, 3, etc. Table No. 3 shall be used in sizing distribution panels for future space allocation.

**Table No. 3**

**Distribution Panel Sizing**

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

<u>Maximum Active Poles</u>		<u>Minimum Spare Poles</u>		<u>Total Poles</u>
12		6		18
24		6		30
36		6		42

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

**E.4.29. Electrical Closets**

Electrical closets generally contain branch circuit panelboards. The closets require adequate space for code-required clearances, lighting, ventilation, and two duplex receptacles. In new work and complete renovations, electrical closets shall be minimum 5 ft. x 8 ft. for closets without transformers and minimum 6 ft. x 10 ft. for closets with transformers. Closets with transformers shall have ventilation (and/or cooling) sufficient for 100% of the total transformer kVA expressed in watts of heat load. Electrical closets shall be located such that the farthest 120 V device served is within a 75 ft. radius of the closet. Loads served with 277 V shall be no more than a 100 ft. radius from the closet. Obviously building configuration will dictate closet location, but the 75 ft. and 100 ft. rule shall be maintained to avoid having to increase branch circuit wires size for voltage-drop reasons. If the above-closet space is not available in small renovation work, shallow closets with full doors on the long wall are acceptable in corridors. Electrical closets within multistory buildings shall be stacked. The closets shall not be located adjacent to mechanical shafts so as to avoid interference problems with ducts and conduits above the ceiling directly outside the closet. Mechanical ducts, etc. shall not run through electrical closets as stated above per the NEC. Lighting in electrical closets shall be one two-lamp fluorescent strip for the small closet and two fixtures for the large closets. The lighting shall be connected to emergency power when available. One duplex receptacle shall be wired to emergency power and one to normal power in each electrical closet. During renovation work, the designer shall not obtain new circuits from panelboards in remote areas or other floors of the building. Holes in the floors of electrical closets shall be sealed watertight. Wherever possible, the floor shall be provided with sleeves extending at least 2.75 in. above the floor.

**E.4.30. Receptacles**

The standard color for receptacles is white. Receptacles serving computers shall ground circuits are required, an isolated ground conductor (see section E.4.23, Wire Color Coding) shall be installed with the branch circuit. See section E.8, Power Quality, for panelboard isolated ground bus requirements. Receptacles specifically designated as serving printers shall be blue. Receptacles connected to emergency power shall be red. Receptacles shall be installed such that the ground prong is mounted in the down position. Offices shall have minimum one general (white) receptacle per wall. General-purpose receptacles shall have a design load of 180 VA each in accordance with the NEC. For circuiting purposes a maximum of six receptacles shall be connected to a circuit. This allows a future expansion of two receptacles per circuit. Personal computers (PCs) shall be limited to three per 20 A circuit. Printers shall be limited to two per 20 A circuit. Computer and printer receptacles shall not be connected to the same

circuit, nor to the general (white) receptacle circuits. A 20 A duplex receptacle shall be mounted within 25 ft. of and on the same level as any electrically operated equipment on rooftops, in attics, and in crawl spaces. The receptacle must be on a separate circuit than that serving the equipment. Receptacles mounted outdoors shall be GFI type. Tamperproof safety-type receptacles are required in child care areas. Tamperproof receptacles shall operate with a 2 or 3 prong plug. Special duplex or single receptacles to serve specific equipment or loads shall be indicated by NEMA configuration.

#### **E.4.31. Demolition**

Where the work requires that wiring be removed from conduit that is not embedded in concrete, and if that conduit is not scheduled for reuse on the same project, then the conduit is to be removed. Exception: The lighting switch leg conduit is connected to the first outlet box if wall containing switch is to remain. Or vertical conduit is connected to the first outlet box at panelboard if the panelboard is of the recessed type. Where the work requires that the wiring be removed from an embedded-in-concrete conduit, and if that conduit is not scheduled to be reused, the conduit is to be abandoned in place. Conduit that enters the slab from below is to be cut, after the wires are removed, as close to the slab as practical but with not more than 0.75 in. protruding. Conduit that enters the slab from above shall have the floor material removed so that the conduit can be cut with a cold chisel at least 0.25 in. below the slab elevation, and then the conduit and enlarged opening shall be plugged with non-shrinking grout and the slab surface finished flat and true.

#### **E.4.32. Disconnects**

Disconnect switches shall have a minimum clear mounting height of 18 in. above accessible grade outdoors and 3 ft. above finished floor in interior spaces.

#### **E.4.33. Electric Heat**

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

#### **E.4.34. Nameplates**

All electrical equipment shall have nameplates identifying the name of the piece of equipment or the name of the equipment served (disconnects, starters, etc.). Nameplates shall be laminated phenolic legend plates with black letters on white surround for normal power, white letters on a red surround for emergency power and red letters on a white surround for stand-by power. Nameplates shall have minimum 0.25 in. high letters for small equipment and disconnects, 0.5 in. high for medium-sized wall mounted equipment such as panelboards and individual Size 2 starters and above, and 2 in. high for freestanding equipment such as large panelboards, switchgear, and transformers. The nameplates shall be attached with stainless steel screws. Where the equipment is remote from its electrical source under the equipment name in smaller letters the words FED FROM followed by the source panel or riser name shall be included.

#### **E.5. Emergency Power**

Historically WSU has experienced outages of 30 minutes or less once a year and outages of 2 hours or less once in 20 years. Generators are exercised bi-annually, and automatic transfer switches (ATSs) are exercised annually. The exercising of an ATS causes two momentary outages to the load, one going to diesel power and one returning to normal. Generators shall be rated for 100% non varying continuous load, not Standby or prime rating.

### **E.5.1. Outdoor Generator**

The preferred generator location is outdoors in a sound-attenuated enclosure with adequate working space about the generator. Consideration shall be given to diesel exhaust, feeder length, aesthetics, space requirements, ease of removal, air intakes, etc. when locating the generator on the site. The sound attenuated enclosure shall provide 70 to 79 dB maximum noise level 20 ft. from the enclosure at rated output regardless of the generator size. The generator location shall have self contained battery powered lighting on both sides of the generator(s) connected to emergency power. The generator exhaust silencer, or muffler, shall be critical grade rated or quieter to achieve the required sound rating. The location and direction of the engine exhaust shall not adversely affect the air intake for the building. The preferred direction of the exhaust is up, from a sound rating standpoint. A hinged rain cap shall be provided on vertical discharge exhaust pipes. An on-site minimum fuel storage capacity of 96 hours run time at 100% load shall be provided. Fuel-tank leak detection shall be provided. The battery charger shall be connected to emergency power. The jacket water heaters shall be connected to normal power. Where an oil circulation pump is provided to circulate oil through the engine top end, it shall be connected to normal power. The diesel distribution system is defined as the system delivering power from the generator to the emergency terminals of the automatic transfer switch (ATS). Diesel power is normally dead until the generator is on line. Normal power is delivered to the normal terminals of the ATS. Emergency power starts at the load terminals of any ATS. Diesel power is distinguished from normal power which is live normally, and emergency power which is live all the time except during the brief engine start-up period (5-10 sec.). Where two or more ATS's will be installed, an emergency diesel distribution panel EDDP shall provide for future addition of ATS's with minimal interruption to the diesel power system. The number of switched poles (three or four) in a transfer switch shall match the existing where replacement or upgrade is occurring. The lifting of the generator neutral to ground bond shall comply with NEC requirements for three-pole, solid neutral transfer switches. New construction or complete renovation projects shall utilize four-pole switches on three-phase, four-wire systems. The generator neutral shall be grounded when using four-pole switches in accordance with NEC requirements. ATSS shall have override switches to cause them to transfer to the other source only if it is a good source. A "good source" is defined as one with line voltage + 10% available and frequency of 60 Hz + 1/2%. ATSS shall have external manual operators (EMOs) to mechanically operate the ATS under load without opening the enclosure door. Pushbuttons shall not be used as EMOs. The EMO shall transfer the switch to any position regardless of the condition of the source. ATSS without center off time delay shall have an in phase band monitor. ATSS shall have center off time delay when serving motors. ATSS shall be located indoors. If a waiver is granted for an outdoor location, the ATS shall have door-in-door NEMA Type 4X construction with strip heaters inside the enclosure. The strip heaters shall be connected to emergency power. The transfer switch shall be UL listed in accordance with UL 1008. The ATS shall be provided with a complete Square D powerlogic metering package supplied on the load side of the device. These meters shall monitor the load whether the source is normal or diesel power. Metering shall consist, as a minimum, of voltmeter (phase to phase and phase to neutral), ammeter (per phase and average three-phase), frequency meter, and kW demand meter, plus associated switching devices. The operating mechanism of the transfer switch shall be electrically operated, mechanically held. ATS's shall not be manufactured utilizing two circuit breakers with the trip handles physically connected. The cable connection points for the two inputs and load shall have a phase-to-phase spacing of at least 2.75 in. Bypass transfer switches shall be used where the load cannot be taken out of service or the scheduling of an outage is extremely difficult. Transfer switches shall be maintained once a year. With a bypass switch the transfer switch can be taken out of service with only a momentary outage to the load. The user shall be made aware of the added cost of a bypass transfer switch so as to make an educated decision. The size of a transfer switch will also increase with the addition of the bypass function. The bypass switch shall be capable of manual operation to either source, under load, regardless of the condition of the source or transfer switch position. The manual operator shall be readily and permanently accessible without opening the enclosure door.

### **E.5.2. Indoor Generator**

If site constraints are such that the generator must be located indoors, the following design requirements apply. Provide sound attenuated room to suit the generator being installed and the surrounding occupancies. The design for the volume of air delivered to the interior space where a generator is located must include the combustion air that exits out the exhaust stack and the cooling air that flows through the radiator. Note that the air that flows through the engine radiator is heated, and this expanded air, if used for combustion, will reduce the engine efficiency. The cost of conditioning the air to be used for the needs of the generator dictates that outside air be used wherever possible. This requirement has no impact upon combustion air, but cooling with outside air will require that the coolant in the generator contain a chemical antifreeze ingredient. The outside air intake for combustion air shall be coordinated so that there is little chance that the building exhaust (which might contain smoke in a fire situation) will be drawn in for combustion air. The ventilation air intake shall be coordinated such that it does not draw in engine exhaust. Where the engine exhaust from the indoor generator exits the building through a wall, or penetrates interior floor slabs or the roof, an insulating thimble must be used to protect adjacent materials from the excessive heat that would be created by full load operation. The design that places a generator within a new building must also provide a suitable exit route for removal of this equipment shall replacement be necessary in the future. This route shall be clearly delineated on the drawings. The air for either cooling or combustion purposes shall be primary filtered as it enters the building from outside. The engine filter shall be considered a second and final filter for indoor units. The following loads are required to be connected to emergency power. These loads are in addition to any code required emergency loads:

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

The following loads may be connected to emergency power:

- CCTV cameras and equipment
- Security system

A duplex receptacle on the emergency system shall be placed in the corridor within 20 ft. of each stairwell entrance. This receptacle is primarily for the use of Fire Department in emergency situations and shall be so marked with appropriate signage so that the receptacle will not be blocked or hidden by equipment.

### **E.5.3. Fire Pumps**

Where a generator is required or desired, and where a fire pump is required, it shall be connected to the generator. The fire pump emergency diesel feeder shall be connected at the generator where one generator provides emergency power to the building. The fire pump feeder shall be connected to a separate main circuit breaker from the building emergency diesel feeder. The fire pump circuit breaker shall be sized to start the fire pump with all other fire pump room loads on the feeder energized. The generator shall be sized to start the fire pump with all other loads connected to the generator energized. Load dumping of nonessential loads is allowed prior to starting the fire pump. If the building emergency power system consists of multiple generators paralleled to a bus, then the fire pump diesel feeder shall not be connected at the generator. If the paralleling switchgear distribution circuit breakers are housed in switchgear construction with individual breaker compartments, then the fire pump feeder shall be connected in the paralleling switchgear. The fire pump feeder switch shall be in the bottom compartment of one of the switchgear sections. The distribution switchgear shall be fused switches similar to the normal service secondary switchgear. If the paralleling equipment is not switchgear construction on the distribution end, then the fire pump overcurrent device shall not be in the paralleling switchgear. The fire pump feeder shall be tapped ahead of any distribution switches and feed a separately mounted overcurrent device. The overcurrent device shall be mounted on a wall in the room with the paralleling equipment. The enclosure shall be painted red and clearly labeled FIRE PUMP EMERGENCY DISCONNECT in 1 in high white letters. The fire pump feeder from the emergency source to the fire pump controller shall be installed in accordance with NFPA Standard 20. The ATS for the fire pump shall be in the fire pump room. The

transfer switch shall be supplied with the fire pump controller. The routing of the normal and diesel feeders to the fire pump room shall be separate. The jockey pump, lighting, receptacles, etc. in the fire pump room shall be connected to emergency power and not to the fire pump feeder.

### **E.6. Motor Control**

Motors shall be operated on the system voltage noted in Table No. 4. Motors with ratings other than those listed shall not be connected. Thermal manual motor starters (TMMS's) shall be of the non-automatic resetting type and shall be lockable in the off position. Three-phase motor starters shall be sized by the NEMA rating. Motors 37,300 W and larger shall have reduced-voltage starters. Motor starters shall be combination type with a fused disconnect switch. Three-phase motor starters shall have integral single-phase protection against loss of any phase voltage. Solid-state overload relays provide this function inherently. Pilot devices to be included in three-phase motor starters are:

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

**Table No. 4**

<b><u>Motor Rating (V)</u></b>	<b><u>System Voltage (V)</u></b>
115	120
200/208	208
460	480

Motor control centers (MCCs) shall be provided where six or more motors are located in an area and need to be interlocked. MCCs shall have copper bus and plug-in starters with no hard wiring directly to the starter. All control wiring (in or out) shall be extended to terminal strips in a central location in the MCC in accordance with NEMA Standard ICS 2-322, Type C wiring. Motor starters shall conform to IEC 947-4-1 Type 2 component protection in the event of a short-circuit. Ladder diagrams and sequences of operations shall be provided for all control functions. This applies to heating, ventilating, and air conditioning (HVAC), automatic temperature controls (ATC) (pneumatic or electric), plumbing, fire protection, security, programmable lighting control, etc. Motor starter enclosures shall be NEMA Type 1 indoors, NEMA Type 4 outdoors, and NEMA 4X in corrosive environments. High-efficiency motors shall have the overcurrent protection sized in accordance with the manufacturer's recommendations. Variable-frequency (speed) drives (VFDs) shall be as specified by the mechanical engineer, to yield better coordination between the motor, the drive, and the driven piece of equipment. Power factor correction capacitors shall be applied to motors 7.5 kW and larger. The capacitors shall be wired directly to the motor terminals.

### **E.7 Lighting**

Lighting requirements shall follow the IESNA *Handbook* unless otherwise noted. The most common lighting fixtures on WSU campus are the recessed 24 in. x 24 in and 24 in x 48 in. fluorescent troffers. All 24 in. x 48 in. fluorescent troffers shall meet the criteria in Table No. 5:

**Table No. 5**

#### **Criteria for Fluorescent Troffers**

Description Criteria

24 in x 48 in., 24 in x 24 in, and 12 in. x 48 in.

Depth: 10.75 in.

Body Metal Thickness: 22 gauge

Endplate Metal Thickness: 20 gauge

Door Material: Aluminum with mitered corners

Door Latches: Cam type

Paint Reflectance 90%, pre- or post-painted 2x4 Coefficient of Utilization (CU): .89 minimum at room cavity ratio (RCR) of 1.0 and ceiling/wall/floor reflectances of 80%/50%/20%.

2x2 Coefficient of Utilization (CU): .83 minimum at RCR of 1.0 and ceiling/wall/floor reflectances of 80%/50%/20%.

1x4 Coefficient of Utilization (CU):.79 minimum at RCR of 1.0 and ceiling/wall/floor reflectances of 80%/50%/20%.

Lens: .125 in. thick pattern 12 100% acrylic with flat prism surfaces or Reflector: 18 cell parabolic, 9 cell parabolic, or 6 cell parabolic

Lamps: (3) F32T835 W (3) PL-L 40W/35/RS, (2) F32T835,

### **E.7.1 Lamps**

Fluorescent 4 ft. lamps shall be 25W, T8, 3,500 K color temperature with a CRI of 86 or higher and rated average life of 46,000 hours. Compact fluorescent lamps shall be 3,500 K color temperature with a CRI of 82 or higher and rated average life of 10,000 hours. The compact fluorescent lamp wattage shall vary according to the application. Compact fluorescent lamps are recommended in all but the most critical color rendering applications. In those few specific applications, incandescent lamps may be utilized. The PAR halogen infrared (HIR) lamps are recommended for lumen output of 1,150, lamp life of 3,000 hours. Standard incandescent PAR and R lamps shall not be specified. Halogen versions of the PAR and R lamps shall be submitted for the standard incandescent. Finished rooms or spaces with 10 ft. minimum ceilings may utilize metal halide (MH) lamps. Open fixtures shall be utilized only with metal halide lamps rated for same. Metal halide lamps shall have a color temperature of 3,200 K, rated life of 5,000 to 15,000 hours depending on the wattage, and a minimum CRI of 65.

### **E.7.2. Fluorescent Lamp Ballast**

Ballast shall be solid-state electronic type consisting of rectifier, high-frequency inverter, and power control and regulation circuitry. Ballast shall be UL listed, Class P thermal rating, and Class A sound rating, per UL935-84 and certified as follows by lighting Electronic Testing Laboratory (ETL) or UL and labeled by Certified Ballast Manufacturers Association (CBM). Ballast shall be rated for the actual number of lamps served, and the voltage shall match the connecting circuit voltage. Ballast shall have an operating frequency of 20 kHz or greater. Ballast shall contain no polychlorinated biphenyls PCBs. Light regulation shall be plus or minus 10% with nominal plus or minus 10% voltage variation. Lamps shall be operated in rapid-start mode. Ballast shall be designed to withstand transients described in IEEE Standard 587, Category A. Ballast temperature rise shall not exceed 25°C over 40°C ambient. Ballast shall meet Federal Communications Commission (FCC) regulations, Part 18. Ballast shall have a minimum 5-year warranty

### **E.7.3. Exterior Lighting**

All exterior lighting shall be Metal Halide. Lighting designers shall be concerned about light pollution, or the intrusion of WSU light on bordering neighbors. The use of "house side shields" on fixtures, or light fixtures with good "cut-off" optics for glare control shall be utilized near WSU property line. The placement of lighting poles near the property line shall be avoided and will be scrutinized by WSU. Site lighting poles shall have a 3 in. x 1 in. aluminum tag riveted to the pole. The tag shall clearly identify the building, panel, and circuit number where the service is derived. Street lighting shall utilize a shoe box fixture mounted 30 ft. above the pavement with a 400 MH lamp. Where poles are placed immediately at the edge of a parking lot or other areas where automobile bumpers may come in contact, the pole shall be mounted on a 3 ft. high concrete base for protection. The pole shall be shortened accordingly to maintain the 30 ft. mounting height. All exterior lighting circuits are to be controlled at their point of origin by a lighting contactor. The lighting contactor shall have a 24VAC coil and a hand/off/auto switch with red

and green pilot lights. This is so the circuit can be energized during the day for trouble-shooting purposes. Site lighting circuits shall use minimum #6 AWG wire in minimum 2.5 in. PVC schedule 80 conduit. The maximum circuit breaker size protecting site lighting circuits shall be 30 A. The plastic conduit is placed at least 24 in. below finished grade with a 6 in. wide plastic warning tape with a metallic tracer strip placed above it at 6 in. below finished grade. When a new street lighting pole is installed, it is required to have a 10 ft. long, 0.75 in. diameter, copper-clad ground rod placed in the foundation, and all metallic components shall be grounded to the rod, such as the metal standard, the ground wire pulled in with the power circuit, and an equipment ground wire to the luminaire. Outdoor lighting circuits shall not have underground splices or tee splices. If splices are necessary, they shall only occur in accessible locations in light pole bases. Walkway lighting fixtures are typically mounted on 14 ft. poles with 250 MH lamps. Walkway lighting shall be shoe box fixtures and match the fixtures in the area. All exterior lighting shall be of the glare control type with a flat lens rather than the drop-lens type. A lighting fixture schedule shall list at least three manufacturers and model numbers. A note indicating "or approved equal" shall be included at the bottom. Recessed fluorescent lighting fixtures shall be supported from the building structure on all four corners independent of the ceiling construction. Steel wire shall be minimum 0.125 in. diameter. Site-lighting circuit voltages of existing circuits may be obtained from WSU. Animal loading docks and food service loading docks shall use MH lighting. Loading docks shall be provided with 120V source(s) for bug "zapper" fixtures. The electrical lighting plan drawings shall contain enough information so that the number of wires in each conduit run is easily discernible.

#### **E.7.4. Interior Lighting**

The office average maintained light level using a maintenance factor of 75% shall be 60 to 80 ft.-candles. For values in other types of spaces confer with the Electrical engineer at WSU. Circuit connections to lighting fixtures shall be made with minimum 0.5 in. flexible metal conduit, maximum 6 ft. in length. Lighting fixture pendants shall be minimum 0.5 in. diameter stems with swivel mounts. Industrial fluorescent lighting fixtures shall have a wire guard or plastic sleeves over the lamps. Shelf-mounted, open-strip light fixtures shall also have plastic sleeves over the lamps. The use of switch labels and corresponding labels at each fixture is not sufficient. The Contractor shall not have to lay out the room wiring diagram (i.e., perform the design function) in order to determine the number of conductors needed between fixtures or between fixtures and switch locations.

#### **E.7.5. Exit Signs**

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

### **E.8. Power Quality**

#### **E.8.1. Grounding**

A solid-grounding electrode system shall be provided to ground the service entrance equipment. Where an exterior pad-mounted transformer is utilized, a ground ring of #4/0 AWG bare copper conductors shall be provided around the transformer pad. Ground rods shall be placed approximately 3 ft. outside each corner of the pad. Two #4/0 AWG conductors shall be brought up into the transformer enclosure for equipment grounding. The transformer neutral shall only be grounded inside the service entrance (SE) equipment in the building. A #4/0 AWG ground conductor shall extend from the outdoor ground ring underground to the main electric room ground bus. Ground conductors shall be connected to a wall-mounted ground bus. The ground bus shall be 2 in. x 0.25 in. x 24 in. copper. The ground bus shall be mounted 18 in. above finished floor (AFF). Grounding conductors leading to the ground ring shall be exothermically welded to the ground bus; all others shall be bolted. Equipment and grounding electrode

conductors (all bolted conductors) shall be labeled. Labeling shall utilize embossed brass metal tags with nylon tie wraps. Ground conductors brought through the floor or walls shall be in PVC conduit sleeves. Ground conductors shall not be located in traffic areas or where subject to damage. Feeders and branch circuits shall contain equipment ground conductors sized in accordance with the NEC. Panelboards serving isolated ground receptacles shall have an isolated ground bus in addition to the equipment ground bus. The isolated ground bus shall not be bonded to the panelboard enclosure or equipment ground bus. Isolated ground receptacles are typically required in laboratories and offices. The buses shall be clearly labeled. An isolated ground conductor shall be sized to match the phase conductor. The isolated ground conductor shall be isolated to the separately derived power source.

### **E.8.2. Harmonics**

The power supplies found in any computerized equipment such as PCs, laser printers, file servers, electronic ballasts, VFDs, and uninterruptible power supplies (UPSs) impose third-order (180 Hz) and higher harmonic currents on the neutral conductor of three phase, four-wire electrical systems. The triple (multiples of three) harmonics add in the neutral conductor. The worst-case 100% total harmonic distortion would create a neutral current of 1.73 times the phase current. Where a high concentration of computer loads relative to all other non computer loads is anticipated, precautionary measures shall be taken. The following shall be provided where a large percentage (60% or more) of the load is or will be computerized:

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

### **E.8.3. Transients**

Transient voltage surge suppression (TVSS) shall be provided integral on all 120/208V panels. All switchboards shall have TVSS as well built into the unit housing. TVSS protection may be prudent. A layered protection plan is recommended. ANSI/IEEE Standard C62.41 Category C3 TVSS protection shall be provided at the service entrance and Category B3 TVSS protection, at the downstream branch circuit panels.

## **E.9. Fire Alarm**

The engineer shall not make changes to an existing active fire alarm system without the approval of the university electrical engineer. This includes connecting new equipment or systems into the GCC in Allyn Hall. The fire alarm system on campus is manufactured by Simplex and all new equipment provided shall be as manufactured by Simplex for compatibility issues. Each building shall have its own FACP that is a Simplex 4100U control panel. Each control panel shall contain 8 pre-recorded campus standard messages. Each panel shall connect to the GCC in Allyn Hall via a fiber optic loop that shall be enclosed in conduit. All fire alarm system raceways shall have red fittings, boxes, and cover plates. All manual pull stations shall be red and of the addressable type. Also they shall be of the single action type. All visual strobes shall be 110cd regardless of the location. All audible notifications shall be speakers with multiple taps and they shall be set on their highest tap at time of installation. All alterations to the GCC shall be made with new programming and shall include new or updated floor planes. All devices shall be addressable. All smoke/heat detectors shall be addressable and shall be of the analog type. All door hold opens shall be 24VDC. All tamper and flow switches shall be addressable or made addressable with separate modules.

**E.10. Security**

All security monitoring equipment shall be as manufactured by Simplex and shall connect directly to the Simplex fire alarm panel in each building. These points shall be individually addressable and shall be monitored by the GCC in Allyn Hall. This shall include all door contacts, motion sensors, monetary contacts, panic buttons, hold up buttons, etc... The GCC shall be revised and reprogrammed as needed to represent the new points on their respective floor plan.

Emergency phones with blue lights mounted above shall be provided at strategic locations in remote areas, on buildings, and in parking lots. The phones connect the caller directly with the Police Communications Center. When a call is answered, the location of the calling phone is automatically announced in the Police Communications Center to aid in sending help. Where the blue-light phones are located in parking lots, they shall receive power from separate 120V circuits extended out from the nearest building. The site-lighting circuits shall not be tapped underground.