ASU Electrical Reliability Standard

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ASU Electrical Reliability Standard

A. Scope:

1. Define categories of emergency, standby and normal power needed to serve the various loads at the ASU Tempe Campus.
    a. This standard applies to buildings that are not part of the Tempe campus, except that references made in this Standard to the Central Plant (CP) and the Combined Heating and Power Plant (CHP) and the associated 4160V generators are not available sources of power for off-campus buildings.
    b. Existing Buildings: Where modifications are required to bring existing buildings in compliance with this Standard, obtain approval from the ASU executive director of Capital Programs Management Group to make required modifications.
2. Establish design, installation and operational criteria in the electrical systems for the reliable delivery of power to each of the categories of emergency, standby and normal power systems.
3. Develop a method to assign the various loads or processes on campus to one of the power system categories.

B. Codes and Standards: The following codes and standards apply to this document. While many of the requirements from these references are stated in this Standard for emphasis and/or interpretation, it is not the intent to re-state all requirements. The absence of a re-statement of any requirement from the list of codes and standards does not relieve the design engineer from compliance with the codes and standards, which are part of the requirements of this document by reference. Where conflicts occur between this Standard and the references below, notify the ASU Project Manager of such conflicts for resolution and direction.

1. ASU Design Guidelines
2. IEEE Std 446-1995: Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications
3. International Building Code - 2006 (in particular, Chapter 27)
4. NFPA 70: National Electrical Code - 2008 (in particular, Articles 700, 701 and 702)
5. NFPA 110 Standard for Emergency and Standby Power Systems
6. Uptime Institute - Tier Classification and Performance Standard

C. Assumptions: The following assumptions are made:

1. Electrical equipment and components are properly designed to function within their intended application and limits.
2. The design and installation of the electrical system is code compliant.
3. Electrical systems are tested, adjusted and commissioned to meet the design intent.
4. Equipment is operated within its limits and intended use.
5. Personnel are properly trained and qualified to operate the equipment.
6. Equipment is maintained and tested according manufacturer's recommendations and the requirements of applicable codes and standards.

D. Categories of Power Systems: For the purposes of the ASU Reliability Standard, the following categories of power systems are defined below, with requirements given for each category. To the extent possible, established definitions are used and tailored to meet the specific needs of ASU.

E. Emergency System (Category "E"): Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life (NEC 700.1). For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

1. **Examples:** Equipment on campus to be connected to this system may include:

    a. Elevators and Lifts - where 4 or more stories, and where they are part of an accessible means of egress
    b. Emergency Egress and Exit Lighting
    c. Fire Detection and Alarm Systems
    d. Fire Pumps
    e. Public Safety and Emergency Voice Communications Systems
    f. Ventilation - where essential to maintain human life (i.e. BSL3 and BSL4 areas).
    g. Fume hoods, ventilation, treatment systems, temperature control, alarm and detection where pyrophoric materials (silane gas), highly toxic or toxic materials are handled or stored.
    h. Industrial Processes - where interruption would produce serious life safety or health hazards.
    i. Other equipment or systems as required by the referenced codes and standards

2. Requirements for the Emergency System:

a. **Sources of Power:** Loads on the emergency system for each building shall be supplied with two sources of power: the normal power source for the building, and an emergency standby power source connected through an automatic transfer switch located inside of the building served. Depending on availability, capacity and project requirements, the following sources of power for the Emergency System are acceptable on the ASU Tempe Campus:

    1. 4160V generators and distribution from the Central Plant (CP)
    2. 4160V generators and distribution from the Combined Heating and Power Plant (CHP)
    3. Emergency/standby generator(s) located on the premises of the project, with on-premises fuel source.

b. **Capacity:** The emergency power system shall have adequate capacity and rating for all emergency loads to be started and operated simultaneously. A load study for each project shall be performed and submitted to the ASU Project Manager to determine the required capacity of the emergency power system for the emergency loads of the project, and compared to the available capacity if connecting to an existing emergency source of power.

    1. Where connecting to existing generator(s), the existing running load may be determined by metered kW demand data in accordance with NEC 220.87, except that an additional minimum 125% factor shall be applied to account for power factor. Loads that do not normally operate (such as fire pumps and smoke control equipment) shall be added to the metered demand. The simultaneous starting of all emergency loads shall be taken into account in the load calculations.

    2. Where multiple fire pumps are connected to the existing generator(s), a demand factor as approved by the ASU Facilities Director may be applied.

c. **Tolerance Duration of Outage:** The emergency power supply shall be available within 10 seconds of failure of the normal power supply.

d. **Duration of Supply:** The emergency power supply shall be available for 24 hours minimum (based on the maximum kW rating of the generator), without the need to refuel the source.

    1. For buildings with a seismic design category C, D, E, or F as determined in accordance with ASCE 7, the minimum duration of fuel supply shall be increased to 96 hours.

e. **Transfer Equipment:** Automatic transfer switches meeting all UL and NFPA requirements for Emergency/Level 1 installations shall be provided and dedicated to the Emergency System and its loads, and be located inside of the building it serves. Provide bypass isolation for each transfer switch

f. Physical Separation of Systems:

1. Locate generator(s) either indoors in a dedicated 2-hour rated room, or outdoors in a suitable weather-protected housing within an enclosed, secured equipment yard.

2. Locate transfer switch(es) and its main distribution in a 1-hour rated room, separate from the normal power equipment.

    a. Transfer switches and distribution from the legally-required and optional standby systems are permitted to be in this same room.

g. **Electrical Separation of Systems (Independent Wiring):** Wiring from the emergency source and its distribution shall be kept entirely independent of all other wiring and equipment according to NEC 700.9.

1. Where connecting to the 4160V generators from either CP or CHP (or some other central, shared source), the feeder from these sources shall be dedicated to only the Emergency Systems. Where standby loads within a building are connected to this same feeder (as allowed by this Standard), then the independent wiring shall begin at the first main disconnect or switchboard on the secondary side of the 4160V transformer, where separate vertical sections or separately enclosed disconnects shall be used to serve the separate emergency and standby transfer switches.

h. **Selective Load Pickup and Load Shedding:** Selective load pickup and load shedding is not allowed on the emergency systems, but shall be provided for the standby loads that share a common generator or feeder that serves the emergency system.

i. **Selective Coordination:** Overcurrent devices shall be selectively coordinated per NEC 700.27.

1. Coordination shall be provided for a minimum of 0.1 seconds and above (short time and long time regions). For below 0.1 seconds (instantaneous region), consideration may be given to other factors, such as availability of equipment to provide full coordination in this region, and the increased arc flash hazard that may result in full coordination. A fault current, coordination and arc flash study shall be performed on the emergency system for each project and presented to the ASU Project Manager and code authority for discussion and decision on system coordination.

F. Legally Required Standby Systems (Category "S"): Those systems required and so classed as legally required standby by municipal, state, federal, or other codes or by any governmental agency having jurisdiction. These systems are intended to automatically supply power to selected loads (other than those classed as emergency systems) in the event of failure of the normal source. Legally required standby systems are typically installed to serve loads, such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes, that, when stopped during any interruption of the normal electrical supply, could create hazards or hamper rescue or fire-fighting operations (NEC 701.2 and FPN). For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

1. **Examples** of equipment on campus to be connected to the this system may include:

    a. Smoke Control Systems
    b. Electrically Operated Doors
    c. Heating and Refrigeration Systems - where interruption would create hazards
    d. Fume hoods, ventilation, treatment systems, temperature control, alarm and detection where hazardous materials are handled or stored.
    e. High-rise Buildings - fire command center (lights and power)
    f. Sewage Disposal
    g. Other equipment or systems as required by the referenced codes and standards

2. Requirements for the Legally Required Standby System:

a. **Sources of Power:** Loads on this system for each building shall be supplied with two sources of power: the normal power source for the building, and a standby power source connected through an automatic transfer switch located inside of the building served. Depending on availability, capacity and project requirements, the following sources

of power for the Standby System are acceptable on the ASU Tempe Campus:

1. Standby generator(s) located on the premises of the project, with on-premises fuel source.
2. 4160V Generators and distribution from either CP or CHP, *for small loads*: For small loads where an on-premises generator does not exist or may not be justified, the campus 4160V generator systems may be used, with approval from the ASU Director of Facilities.

b. **Capacity:** The standby power system shall have adequate capacity and rating for all loads intended to operate simultaneously. Starting may be accomplished with load-stepping to minimize generator size due to block load pick up and inrush currents, as long as the Tolerance Duration of Outage is not exceeded. A load study for each project shall be performed and submitted to the ASU Project Manager to determine required capacity of the standby power system for the loads of the project, and compared to the available capacity if connecting to an existing standby source of power.

1. Where connecting to existing generator(s), the existing running load may be determined by metered kW demand data in accordance with NEC 220.87, except that an additional minimum 125% factor shall be applied to account for power factor. Loads that do not normally operate (such as fire pumps and smoke control equipment) shall be added to the metered demand.

2. Applicable NEC demand factors for elevators and non-coincidental loads may be applied to new loads. Submit demand factor analysis together with the load study.

c. **Tolerance Duration of Outage:** The standby power supply shall be available within 60 seconds of failure of the normal power supply. Specific load(s) may require shorter outage duration, and shall be verified with the ASU Project Manager and User groups for each project.

d. **Duration of Supply:** The standby power supply shall be available for 24 hours minimum (based on the maximum kW rating of the generator), without the need to refuel the source. Specific load(s) may require longer duration of supply, and shall be verified with the ASU Project Manager and User groups for each project.

e. **Transfer Equipment:** Automatic transfer switches meeting all UL and NFPA requirements for Legally Required/Level 2 installations shall be used for the Legally-Required Standby System, and be located inside of the building it serves. Provide bypass isolation for each transfer switch

f. **Physical Separation of Systems:**

    1. Locate generator(s) either indoors in a dedicated 2-hour rated room, or outdoors in a suitable weather-protected housing within an enclosed, secured equipment yard.

    2. Locate transfer switch(es) and its main distribution in a 1-hour rated room, separate from the normal power equipment.

        a. Transfer switches and distribution may occupy the same room as the Emergency System transfer switch and distribution.

g. **Electrical Separation of Systems (Independent Wiring):** Wiring from the standby source and its distribution shall be kept entirely independent of the normal power wiring and equipment.

    1. Where standby loads within a building are connected to the 4160V generators and feeder (as allowed by this Standard), then the independent wiring shall begin at the first main disconnect or switchboard on the secondary side of the 4160V transformer, where separate vertical sections or separately enclosed disconnects shall be used to serve the separate emergency and standby transfer switches.

h. **Selective Load Pickup and Load Shedding:** Selective load pickup and load shedding is permitted providing all other requirements are met, in order of highest priority to lowest priority as listed below. Submit proposed load pickup/load shed scheme to the ASU Project Manager and User groups for approval.

    1. Emergency Circuits (never shed)
    2. Legally-Required Standby Circuits
    3. Critical Standby
    4. Less Critical Standby

i. **Selective Coordination:** Overcurrent devices shall be selectively coordinated per NEC 701.18.

1. Coordination shall be provided for a minimum of 0.1 seconds and above (short time and long time regions). For below 0.1 seconds (instantaneous region), consideration may be given to other factors, such as availability of equipment to provide full coordination in this region, and the increased arc flash hazard that may result in full coordination. A fault current, coordination and arc flash study shall be performed on the standby system for each project and presented to ASU (Authority Having Jurisdiction) for discussion and decision on system coordination.

G. Critical Standby Systems: Critical standby systems are those systems intended to supply power to facilities where life safety does not depend on the performance of the system. Critical standby systems are typically installed to provide an alternate source of electric power for such facilities as industrial and commercial buildings to serve loads such as heating and refrigeration systems, data processing and communications systems, and industrial processes that, when stopped during any power outage, could cause discomfort, serious interruption of the process, damage to the product or process, or the like1 (NEC 702.2 and FPN). This category will be divided into three subcategories:

1. **Critical (Category "C1"):** Those systems intended to supply power to facilities or processes that, when stopped or disrupted during any power outage, could cause substantial economic loss, damage products or animals, result in loss of experimental, research or computational data, or the like. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

    a. Examples of equipment on campus to be connected to the this system may include:

        1. Critical Research Lab Equipment
        2. Freezers and Refrigerators - Labs
        3. Vivariums: HVAC (with control systems) and Lighting
        4. Elevators for Research and Other Critical Buildings (if not already on the Emergency System as required by that section).
        5. Data Centers - power and air conditioning
        6. Telecommunications Systems (UTO), MDF Rooms - core locations: power and air conditioning
        7. Building Automation Systems - control panels and circuits
        8. Energy Information System (EIS) - control

1 The NEC refers to these systems as "Optional Standby", however, ASU prefers the term "Critical Standby" to avoid the perception among those operating and using the critical facilities that these systems might be an "option" for their critical buildings. When a building or loads within a building are deemed "critical", then the standby requirements in this Standard are not an option.

9. Mass Notification Systems

2. **Less Critical (Category "C2"):** Those systems intended to supply power to facilities or processes that, when stopped during any power outage, could cause modest economic loss, production loss, discomfort or inconvenience. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.
    a. Examples of equipment on campus to be connected to the this system may include:

        1. Less Critical Lab equipment
        2. Vivariums: Humidification
        3. Freezers and Refrigerators - Food Service
        4. Telecommunications Systems (UTO), MDF Rooms - non-core locations, IDF Rooms: power and air conditioning (including control systems)
        5. Departmental Server Closets (less critical) - power and air conditioning
        6. Security Systems
        7. Points of Sale

3. **Temporary Critical (Category "C3"):** Those systems intended to supply power to temporary facilities, events or processes that, when stopped during any power outage, could cause economic loss, production loss, discomfort or inconvenience. These facilities serve critical functions on a temporary or not regularly recurring basis.
    a. Examples of equipment on campus to be connected to the this system may include:
        1. Temporary Emergency Shelters
        2. Special Events

4. Requirements for Critical, Less-Critical and Temporary Critical Standby Systems:

a. **Sources of Power:** Loads on this system for each building shall be supplied with two sources of power: the normal power source for the building, and a standby power source connected through a transfer switch. The normal source shall fed from a looped campus distribution system normally supplied from a minimum of two separate APS substation transformers. For Critical buildings, it is preferred, but not required, to provide a loop that is fed from both CHP and one other independent APS source. Depending on availability, capacity

and project requirements, the following sources of power for the Critical Standby systems are acceptable on the ASU Tempe Campus:

1. Standby generator(s) located on the premises of the project, with on-premises fuel source.

2. Where an on-premises generator is not provided, the 4160V generators and distribution from either CP or CHP may be used for the small, incidental critical loads that occur in every building, for example:
    a. Telecommunications systems (UTO rooms): power and air conditioning
    b. Security Systems
    c. Points of Sale
    d. Building Automation Systems - control panels and circuits.

3. Provisions for Portable Generators: Where buildings will serve temporary critical functions, provisions for a portable generator connection in lieu of a permanent generator is permitted.

b. **Capacity:** The Critical Standby power system shall have adequate capacity and rating for all loads intended to operate simultaneously. Starting may be accomplished with load-stepping to minimize generator size due to block load pick up and inrush currents, as long as the Tolerance Duration of Outage is not exceeded. A load study for each project shall be performed and submitted to the ASU Project Manager to determine required capacity of the standby power systems for the loads of the project, and compared to the available capacity if connecting to an existing standby source of power.

    1. Where connecting to CHP for normal power, or existing generator(s) for standby power, the existing load may be determined by metered kW demand data in accordance with NEC 220.87, except that an additional minimum 125% factor shall be applied to account for power factor. Loads that do not normally operate (such as fire pumps connected to emergency systems or smoke control equipment connected to legally required standby systems or backup air conditioning equipment connected to critical systems) shall be added to the metered demand.

    2. Applicable NEC demand factors may be applied to new loads. Submit demand factor analysis together with the load study.

c. **Tolerance Duration of Outage:** The tolerance of power outage duration will be dictated by each specific critical, less-critical or temporary critical standby load and shall be verified with the ASU Project Manager and User groups during design. The time in which the critical standby power source becomes available shall not affect its ability to supply the legally-required standby and emergency loads.

d. **Duration of Supply:** The standby power supply shall be available for 24 hours minimum, without the need to refuel the source. Specific load(s) may require longer duration of supply, and shall be verified with the ASU Project Manager and User groups for each project.

e. **Transfer Equipment:** Critical loads shall be supplied with automatic transfer switch(es) meeting all UL and NFPA requirements for Legally Required/Level 2 installations , and be provided with bypass isolation. Less-critical and temporary loads shall be supplied with an automatic or manual transfer switch. Bypass isolation is permitted but not required for less-critical and temporary loads.

    1. Transfer equipment for critical and less-critical loads shall be provided with a transfer-inhibit and load-shed contact or other communication means that is capable of remotely shedding the connected loads from the standby power source. Provide interface to the standby source to shed loads in the order of priority (lowest priority shed first) if the source becomes overloaded.

f. Physical Separation of Systems:

    1. Locate generator(s) either indoors in a dedicated 2-hour rated room, or outdoors in a suitable weather-protected housing within an enclosed, secured equipment yard.

    2. Locate transfer switch(es) and its main distribution within the building it serves.

g. **Electrical Separation of Systems (Independent Wiring):** Wiring from the critical standby source and its distribution shall be kept entirely independent of the normal power wiring and equipment

    1. Where connecting to the 4160V generators from either CP or CHP (or some other central, shared source), the feeder from these sources shall be dedicated to only the Emergency Systems. Where critical standby loads within a building are connected to the same feeder (as allowed by this Standard),

then the independent wiring shall begin at the first main disconnect or switchboard on the secondary side of the 4160V transformer, where separate vertical sections or separately enclosed disconnects shall be used to serve the separate emergency and standby transfer switches.

h. **Selective Load Pickup and Load Shedding:** Selective load pickup and load shedding is permitted providing all other requirements are met, in order of highest priority to lowest priority as listed below. It shall be required for the standby loads that share a common generator or feeder that serves the emergency system. Submit proposed load pickup/load shed scheme to the ASU Project Manager and User groups for approval:

1. Emergency Circuits (never shed)
2. Legally-Required Standby Circuits
3. Critical Standby
4. Less Critical Standby

i. **Selective Coordination:** Overcurrent devices for critical standby systems shall be selectively coordinated.

1. Coordination shall be provided for a minimum of 0.1 seconds and above (short time and long time regions). For 0.1 seconds and below (instantaneous region), consideration may be given to other factors, such as availability of equipment to provide full coordination in this region, and the increased arc flash hazard that may result in full coordination. A fault current, coordination and arc flash study shall be performed on the standby system for each project and presented to the ASU (Authority Having Jurisdiction) for discussion and decision on system coordination.
2. Where ground fault protection of equipment is required by the NEC, a second level of ground fault protection downstream from the main ground fault protective device shall be considered to improve reliability and selective coordination of the ground fault protective system.

H. Normal Power System (Category "N"): Any system not classified above, or without emergency or standby requirements.

1. Requirements for the Normal Power System:

a. **Sources of Power:** Loads on the normal power system for each building shall be supplied by an APS feeder from one of the ASU APS service points on campus.

1. The distribution shall be connected in a looped system configuration such that the system can be sectionalized and maintain availability of the normal source to the building it serves. The normal source shall fed from a looped campus distribution system normally supplied from a minimum of two separate APS substation transformers. For Critical buildings, it is preferred, but not required, to provide a loop that is fed from both CHP and one other independent APS source. Main distribution switchgear that serves campus loops shall be provided with a bypass circuit breaker for each feeder circuit breaker in the switchgear lineup.

I. Uninterruptible Systems: Those systems intended to supply power to equipment or processes that cannot tolerate more than 1/4-cycle (4ms) power outage, the result of which would be a hard crash and loss of data. This typically includes computer hardware and other data processing equipment. This category is a subset of one of the power categories described above and will be divided into five subcategories. Reference is made to "Tier Levels" which is taken and adapted from the Uptime Institutes Tier Classification System (*www.uptimeinstitute.org*)

1. **Uninterruptible - Tier 0 (Category "U0")**: Systems requiring uninterruptible power during a normal power outage, and can tolerate a soft shutdown to save data and programs. During the shutdown time, significant heat is not produced that would damage the equipment in the absence of air conditioning. When normal power is restored, the equipment (and air conditioning) is restarted and the process resumes. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

a. **Examples** of equipment on campus to be connected to the this system may include:

1. Small server rooms (other than UTO equipment rooms) that serve individual departments.
2. Small lab equipment with data processing.

b. Requirements for Uninterruptible Category "U0":

1. **Sources of Power:** Computer and data processing equipment on this system shall be supplied with a UPS system that is fed from the normal power source for the building. Standby power

is not provided for the UPS or the air conditioning serving the equipment room. The UPS source may be a small rack-mounted unit, or a central UPS system where the building is provided with one.

2. **Capacity:** The UPS system shall have adequate capacity and rating for all computer or data processing equipment loads, including future projected loads, plus 25%.
3. **Duration of Supply:** The UPS battery supply shall allow adequate time to perform a soft shutdown of the computer and data processing equipment. Verify battery supply time with the ASU Project Manager and User groups during design.
4. **Redundancy:** Not required.
5. **Selective Coordination:** Not required.

2. **Uninterruptible - Tier 1 (Category "U1"):** Those systems requiring uninterruptible power during a normal power outage and are required to maintain operation. Air conditioning serving the room is required to have standby power. These systems are less critical and can tolerate occasional outages due to planned maintenance or unplanned failures, and therefore no redundancy is planned in the UPS and air conditioning for these systems. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

   a. **Examples** of equipment on campus to be connected to the this system may include:

      1. Small UTO IDF server closets in each building.
      2. Non-Core UTO MDF rooms in each building.
      3. Building Automation Systems - control panels and circuits.

   b. Requirements for Uninterruptible Category "U1":

      1. **Sources of Power:** Computer and data processing equipment on this system shall be supplied with a UPS system that is fed from the critical standby power source for the building. Air conditioning serving the computer room and UTO rooms is also connected to standby power. The UPS source may be rack-mounted units located in each closet, or a central UPS system where the building is provided with one.
      2. **Capacity:** The UPS system shall have adequate capacity and rating for all computer and data processing equipment loads, including future projected loads, plus 25%.
      3. **Duration of Supply:** Minimum battery time of 10 minutes, however, more battery time may be required depending on specific application or user requirements. Verify battery supply

time with the ASU Project Manager and User groups during design.

4. **Redundancy:** Not required.
5. **Selective Coordination:** System shall be selectively coordinated as per the Critical Standby Requirements.

c. Small UTO IDF Rooms in Buildings without a Standby Power System: Where UTO IDF rooms are located in buildings without a standby power system, and the computer equipment load is less than 10,000 watts, extended UPS battery time may be provided in lieu of a standby power source, with battery run time of not less than 4 hours based on the equipment load. Under this condition, the computer equipment shall operate without air conditioning with no damage or failure to the computer equipment during the battery run time.

3. **Uninterruptible - Tier 2 (Category "U2")**: Those systems requiring uninterruptible power during a normal power outage and are required to maintain operation. Air conditioning serving the room is required to have standby power. These systems are critical but can tolerate occasional outages due to unplanned failures. Redundancy is required in the UPS and air conditioning systems, but only a single path is provided to the equipment. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

   a. Examples of equipment on campus to be connected to the this system may include:

      1. None identified at this time

   b. Requirements for Uninterruptible Category "U2":

      1. **Sources of Power:** Computer and data processing equipment on this system shall be supplied with a UPS system that is fed from the critical standby power source for the building. Air conditioning serving the computer room is also connected to standby power. The UPS source may be rack-mounted units located in each closet, or a central UPS system where the building is provided with one.
      2. **Capacity:** The UPS system shall have adequate capacity and rating for all computer or data processing equipment loads, including future projected loads, plus 25%.
      3. **Duration of Supply:** Minimum battery time of 10 minutes, however, more battery time may be required depending on specific application or user requirements. Verify battery supply

time with the ASU Project Manager and User groups during design.

4. **Redundancy:** One additional component (N+1 redundancy) in the UPS and air conditioning systems with a single power path to the equipment.
5. **Selective Coordination:** System shall be selectively coordinated as required by the Critical Standby Requirements above.

4. **Uninterruptible - Tier 3 (Category "U3")**: Those systems requiring uninterruptible power during a normal power outage and are required to maintain operation. Air conditioning serving the room is required to have standby power. These systems are more critical and cannot tolerate outages due to maintenance or unplanned failures. Redundancy is required in the UPS and air conditioning systems, and dual power paths are provided from the UPS output to each data processing equipment rack. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

    a. Examples of equipment on campus to be connected to the this system may include:

        1. Main UTO Telecommunications Core MDF's for each building
        2. Main UTO Campus Data Centers
        3. Equipment as required by contract to be reliable, for example, the JPL/NASA research programs.
        4. Building Automation Systems serving Tier 3 equipment.
        5. Energy Information System equipment.

    b. Requirements for Uninterruptible Category "U3":

        1. **Sources of Power:** Computer and data processing equipment on this system shall be supplied with a UPS system that is fed from the critical standby power source for the building. Air conditioning serving the computer rooms and UTO rooms is also connected to optional-critical standby power. The UPS source will typically be a central system, with isolated and redundant components.
        2. **Capacity:** Each redundant UPS system shall have adequate capacity and rating for all computer or data processing equipment loads, including future projected loads, plus 25%. Where equipment load information cannot be obtained, a basis of 100 watts/sf of equipment room space shall be used, and the

system designed with modular components to easily expand system without requiring a shutdown.

3. **Duration of Supply:** Minimum battery time of 10 minutes for each redundant UPS module at full load, however, more battery time may be required depending on specific application or user requirements. Verify battery supply time with the ASU Project Manager and User groups during design.
4. **Redundancy:** UPS system consists of two separate, redundant systems, each with one or more UPS modules sized for the full load of the equipment. Separate power distribution paths are provided from each system to the equipment racks. Dual power cords of the data processing equipment plug into each system. If one system fails, the other system assumes the full load. Air conditioning requires "N+1" redundancy at a minimum, with a reliable source of backup cooling when depending only on the campus central chilled water supply.
5. **Selective Coordination:** System shall be selectively coordinated as required by the Critical Standby Requirements above.

5. **Uninterruptible - Tier 4 (Category "U4")**: Those systems requiring uninterruptible power during a normal power outage and are required to maintain operation under all conditions. Air conditioning serving the room is required to have redundant standby power. These systems are most critical and cannot tolerate outages under any circumstance. Total system redundancy is required in the UPS and air conditioning systems, and all normal and standby paths from the utility source to each data processing equipment rack. For each project, submit to the ASU Project Manager a list of loads intended to be connected to this system.

    a. Examples of equipment on campus to be connected to this system may include:

        1. None identified at this time

    b. Requirements for Uninterruptible Category "U4":

        1. **Sources of Power:** Computer and data processing equipment on this system shall be supplied with a two separate UPS systems, each connected to separate utility and critical standby sources that are separate and redundant from each other. Air conditioning serving the computer room is also connected to separate and redundant power sources.
        2. **Capacity:** Both or all UPS systems shall have adequate capacity and rating for all computer or data processing

equipment loads, including future projected loads, plus 25%. Where equipment load information cannot be obtained, a basis of 100 watts/sf of equipment room space shall be used, and the system designed with modular components to easily expand the system without requiring a shutdown.

3. **Duration of Supply:** Minimum battery time of 10 minutes for each redundant UPS system at full load, however, more battery time may be required depending on specific application or user requirements. Verify battery supply time with the ASU Project Manager and User groups during design.
4. **Redundancy:** Total "2N" system isolation and redundancy from the power sources (including utility feeds, main transformers and generators) to the data processing equipment. Dual power cords of the data processing equipment plug into each system. If one system fails, the other system assumes the full load. Air conditioning requires double components connected to the separate power systems. A reliable source of backup cooling is required when depending only on the campus central chilled water supply.
5. **Selective Coordination:** System shall be selectively coordinated as per the Critical Standby Requirements.

Table 1: Summary of Power System Categories and Criteria

Power System	Source	Tolerance of Outage	Duration of Supply	Load Add / Shed	Transfer Equipment	Separation of Systems	Selective Coordination	Redundancy (see note 1)
E	CP or CHP 4160V Gen., Local Gen.	10 SEC.	24 HR	NO	ATS w/Bypass	YES	YES	Not Required
S	Local Gen. Limited CP or CHP 4160V Gen.	60 SEC	24 HR	Allowed	ATS w/Bypass	YES	YES	Not Required
C1	Local Gen., Limited CP or CHP 4160V Gen.	Varies	Varies (24 HR min.)	Allowed	ATS w/Bypass	Recommended	YES, plus 2-level GFI	Loops plus Secondary main-tie-main
C2	Local Gen., Limited CP or CHP 4160V Gen.	Varies	Varies (24 HR min.)	Allowed	ATS or Manual	Not Required	YES	Not Required
C3	Local Gen or Portable Gen	Varies	Indefinite with re-fueling	N/A	ATS or Manual	Not Required	Not Required	Not Required
N	APS for all Buildings CHP + APS for Critical Buildings	N/A	N/A	N/A	N/A	N/A	Per NEC	Looped System
U1	Generator plus UPS	4 ms	10 min. UPS 24 HR. Gen	NO	ATS w/Bypass for Gen.	Not Required	Not Required	"N"
U2	Generator plus UPS	4 ms	10 min. UPS 24 HR. Gen.	NO	ATS w/Bypass for Gen.	Not Required	YES	"N+1" with single path
U3	Generator plus UPS	4 ms	10 min. UPS 24 HR. Gen	NO	ATS w/Bypass for Gen	Not Required	YES	"N+1" "2N" for UPS and distribution
U4	Generator plus UPS	4 ms	10 min. UPS 24 HR. Gen	NO	ATS w/Bypass for Gen	Not Required	YES	"2N"
U0	UPS Only	4 ms	10 min.	Soft Shutdown	None.	Not Required	Not Required	"N"

1. Definition of Redundancy Terms:
   "N": The number of components required to serve the capacity of the system. If one component fails, the system fails.
   "N+1": The number of components required to serve the capacity of the system, plus (1) redundant component. If one component fails, the system maintains operation.
   "2N": A system of "N" components required to serve the capacity of the system, plus one independent, redundant system of "N" components. If one system fails, the other system maintains operation.

J. Requirements Common to All Categories of Power

1. **Power Quality**

    a. Surge Protective Device (SPD): Provide SPD at the main switchboard or distribution panel for each of the normal, emergency and standby systems. Provide at least one additional level of SPD for branch panelboards that serve sensitive electronic equipment.
    b. Lightning Protection: Provide a lightning risk assessment analysis for each building per NFPA 780. When the result is "recommended", provide a lightning protection system for the building with a UL Master label.

2. **Grounding:** In addition to NEC requirements, comply with the following grounding requirements:

    a. All feeders and branch circuits shall be provided with an insulated equipment grounding conductor. The conduit system shall be bonded per NEC, but not be the only path for equipment grounding.
    b. Data centers and main telecommunications rooms shall comply with IEEE Standard 1100-1999, Powering and Grounding Electronic Equipment and be provided with a signal reference grounding grid per that Standard.
    c. Telecommunications and server closets shall be provided with a ground bar, bonded to the electrical grounding electrode system.

3. **Voltage Drop:** Branch circuit conductors shall be sized to keep voltage drop to 3% or below. The total voltage drop on branch circuits and feeders shall not exceed 5%.

4. **Sustainability**

    a. Generator Emissions. Generators shall comply with the highest emissions standards available and in accordance with Tier 4 EPA regulations. The use of diesel particulate filters with oxidation catalysts and burners may be required to reach this level.
    b. Carbon Footprint: The campus carbon footprint shall not be increased by adding generators.

5. **Testing and Maintenance of Generators**

    a. Generators shall be tested and maintained according to the NFPA 110 Standard (Chapter 8) and manufacturer's recommendations and instruction manuals.

        1. This testing shall include at least a monthly test for 30 minutes under load. Refer to NFPA110 and manufacturer for a comprehensive list of testing and maintenance requirements.

6. **Labeling:** Equipment labels shall be provided per the current ASU Design Guidelines, with the following modifications:

    a. Labels for all equipment shall be color coded according to the power system category it is served by, and preceded by the abbreviation used for the category. The following color codes and prefixes shall be used:

        1. Normal System: Black background with white text; "N" prefix.
        2. Emergency System: Red background with white text; "E" prefix.
        3. Legally-Required Standby System: White background with red text; "S" prefix.
        4. Critical Standby System: Orange background with white text; "C1" prefix.
        5. Less Critical Standby System: White background with orange text; "C2" prefix.
        6. Uninterruptible Systems (All): Blue background with white text; "UX" prefix, where X = 0, 1, 2, 3 or 4.

    b. Circuit Identification on Outlets: Outlets connected to an emergency or standby source shall be identified on the face plate with the circuit number serving the outlet, using computer printed clear stick-on labels. Wiring devices connected to a standby generator shall be red devices and plates.

    c. Panel schedules shall be updated whenever additions or modifications are made to circuits.

7. **Metering, Monitoring and Notification**

    a. Provide digital metering at overcurrent protective devices for campus medium voltage loops, for main panelboards or switchboards on each of the normal, emergency and standby systems. Meters shall be networked and report back to Central Plant using the campus Energy Information Systems (EIS) fiber network.
    b. Provide monitoring of each transfer switch for status and position of switch, and report to Central Plant through the EIS network.
    c. Make provisions for automatic notification to Central Plan operations when emergency and critical loads are transferred to the standby generator source.

8. **Electrical Reliability Survey**

    a. For each new project, perform an electrical reliability survey to assess the need for different categories or emergency, standby and uninterruptible power. An Electrical Reliability Survey is included in the Appendix that will assist the design engineer and ASU project manager in this assessment. Submit the results of the survey and propose equipment and loads for each system. A Table is provided for common types of loads on ASU Campus that require emergency, standby and uninterruptible power.

9. **Reliability Analysis**

    a. For each new project, submit an electrical reliability analysis to the ASU project manager. The analysis shall include a narrative of the approach for the project to comply with this Standard, with references and compliance statements to each section of this Standard.

10. **Update of Campus Distribution System One-Line and Model**

    a. For each new project, update the campus medium-voltage system one-line diagram.
    b. For each new project, update the campus electrical design analysis software model for load flow, fault currents and coordination. Presently the analysis software used is SKM Powertools.

11. **Commissioning**

    a. All systems serving emergency, standby and critical applications shall be commissioned by an independent (3rd party) commissioning agent per ASHRAE Guideline 0-2005 standards. This commissioning process shall begin in the early design phase of the project, to ensure that this Standard is met, and continue through building occupancy.

12. System Design and Operation and Maintenance Documentation

    a. A Facility Operators Manual shall be provided for each project. This manual shall be customized for the project to fit the scope of work and complexity of the project. The manual shall be organized and presented according to the ASHRAE Guideline 4 Preparation of Operating and Maintenance Documentation for Building Systems.

13. **Training**

    a. Proper training is key to successful turnover and operation of the building. Training requirements shall be customized to fit the scope of work and complexity of the project. Training shall be provided for all major mechanical, electrical and control systems. Training shall include hands-on experience and include DVD recording and training documents and materials.

14. **ASU Reliability Standard Update**

    a. This Standard shall be reviewed and updated on a biannual (or more frequent) basis.

Table 2: Summary Table of Examples of Loads on ASU Campus with Assignment to Power Categories
(Not all loads are listed)

Load / Equipment	Max. Tolerance Duration of Outage	Minimum Duration of Supply	Category of Power System							Justification
			N	E	S	C1	C2	C3	U-	
Emergency and Life Safety	10 s	2 hr		**X**						Life safety
Emergency and Life Safety, Seismic C - F	10 s	96 hr		**X**						Life safety
UTO Main Data Centers (equipment)	4 ms	15 min batt., 24 hr gen.				**X**			**U3**	Continuation of campus operations
UTO Main Data Centers (A/C)	1 min	24 hr				**X**				Continuation of campus operations; Prevent damaged equipment.
UTO Core MDF Rooms (equipment)	4 ms	15 min batt. 24 hr gen.				**X**			**U3**	Continuation of campus operations
UTO Core MDF Rooms (A/C)	1 min	24 hr				**X**				Continuation of campus operations; Prevent damaged equipment.
UTO non-core MDF Rooms (equipment)	4 ms	10 min batt. 24 hr gen.					**X**		**U1**	Continuation of building operations
UTO non-core MDF Rooms (A/C)	1 min	24 hr					**X**			Continuation of building operations; Prevent damaged equipment.
UTO IDF Rooms (equipment)	4 ms	10 min batt. 24 hr gen.					**X**		**U1**	Continuation of building operations
UTO IDF Rooms (A/C)	1 min	24 hr					**X**			Continuation of building operations; Prevent damaged equipment.
Energy Information Systems	1 min	24 hr				**X**			**U3**	Continuation of information to operate the campus during emergencies.
Department Server Rooms	4 ms	15 min. batt.					**X**		**U0**	Soft shutdown to prevent loss of data
Vivarium Ventilation	10 min.	24 hr				**X**				Prevent animal loss; Prevent research loss

Load / Equipment	Max. Tolerance Duration of Outage	Minimum Duration of Supply	Category of Power System							Justification
			N	E	S	C1	C2	C3	U-	
Vivarium Heating and A/C	50 min.	24 hr				**X**				Prevent animal loss; Prevent research loss
Vivarium Elevators	1 hour	24 hr				**X**				Transport of animals
Research Freezers	1 min	24 hr / indefinite				**X**				Prevent research loss
Fume Hoods, Highly Toxic	10 s	24 hr		**X**						Protection of Human Life
Fume Hoods, Hazardous	1 min	24 hr			**X**					Protection of Health and Safety
BSL 3 and 4 Areas	10 s	24 hr		**X**						Protection of Human Life
BSL 1 and 2 Areas	1 min	24 hr			**X**					Protection of Health and Safety
JPL Research (equipment)	4 ms	15 min batt. 75 hr gen.				**X**			**U3**	Compliance with JPL Contract
JPL Research (A/C)	1 min	75 hr				**X**				Compliance with JPL Contract
Building Automation System	1 min	10 min batt. 24 hr gen.				**X**			**U1**	
Points of Sale	10 min	8 hr					**X**			Continuation of revenue
Emergency Notification Systems	1 min	24 hr		**X**						Continuation of emergency communications
Wireless Comm. Systems (cell phone and repeater towers)	10 min	24 hr					**X**			Continuation of communications

Load / Equipment	Max. Tolerance Duration of Outage	Minimum Duration of Supply	Category of Power System							Justification
			N	E	S	C1	C2	C3	U-	
Temporary Emergency Shelters	Depends on availability of portable gen	Indefinite with re-fueling						**X**		Continuation of shelter during community disaster
Special Events	1 minute (portable gen connected)	Duration of event						**X**		Continuation of event; Continue revenue
(Other)										