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UL 2755

Outline of Investigation for Modular Data Centers

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Summary of Topics

This is the Second Issue of the Outline of Investigation for Modular Data Centers, Subject 2755, which covers pre-engineered data center modules consisting of an outer cabinet or container that houses information technology equipment (ITE) and various support equipment such as electrical service and distribution equipment, HVAC systems and the like.

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1 Scope

1.1 This Outline of Investigation covers Modular Data Centers (MDC). The Modular Data Centers covered by these requirements are pre-fabricated units consisting of an outer enclosure housing ITE and various support equipment such as electrical service and distribution equipment, HVAC systems and the like. Some configurations may have the support equipment housed in a separate enclosure. A typical construction may use a standard ISO shipping container or other structure as the outer enclosure, racks or cabinets of ITE, NEC compliant service entrance equipment and power distribution components, power storage such as a UPS and an air or liquid cooling system.

1.2 These factory-built modules incorporate pre-installed materials and equipment which, after installation, may be concealed and may not be accessible for inspection at the final installation site.

1.3 The modular data centers covered by these requirements are intended for fixed installation either indoors or outdoors based on their construction and resistance to environmental conditions. MDCs intended for outdoor use shall be identified with a NEMA environmental class rating.

1.4 These requirements are intended to demonstrate compliance with the National Electrical Code (NEC), NFPA 70 and other national Codes such as Building, Fire, Plumbing, Mechanical, and the like. Where state or local codes differ from the national codes anticipated by these requirements, determining compliance with these codes is the responsibility of the local authority having jurisdiction.

1.5 When these requirements do not cover a specific technology or construction feature, the applicable requirements of the National Codes shall be used.

1.6 This Outline of Investigation assumes that the final installation of the MDC will be performed by qualified service personnel in accordance with the applicable installation instructions, installation practices and national installation codes. These MDCs are intended for installation subject to approval by the Authority Having Jurisdiction.

2 Equipment, Sub-Assemblies and Components

2.1 Except as indicated in 2.2, equipment, subassemblies and components used as a part of an MDC covered by this Outline of Investigation shall comply with the requirements for that equipment, subassembly or component. See Appendix A for a list of standards covering equipment, subassemblies and components.

2.2 Equipment, subassemblies and components are not required to comply with a specific requirement that:

- a) Involves a feature or characteristic not required in the application of the component in the product covered by this Outline of Investigation; or
- b) Is superseded by a requirement in this Outline of Investigation.

2.3 Equipment, subassemblies and components shall be used in accordance with their ratings and any installation requirements established for the intended conditions of use.

2.4 Equipment, subassemblies and components that are incomplete in construction features or restricted in performance capabilities shall be used only under the specific conditions for which they have been evaluated.

3 Units of Measurement

3.1 Where a value for measurement is followed by a value in other units in parentheses, the first stated value is the requirement.

4 Undated References

4.1 Any undated reference to a code or standard appearing in the requirements of this Outline of Investigation shall be interpreted as referring to the latest edition of that code or standard.

5 Glossary

5.1 For the purposes of this Outline of Investigation the following definitions apply.

5.2 **APPLIANCE** – A piece of utilization equipment that incorporates both controls and loads.

5.3 **BRANCH CIRCUIT** – The conductors and components following the last overcurrent protective device protecting a load.

5.4 **BRANCH CIRCUIT PROTECTION** – Overcurrent protection with an ampere rating selected to protect the branch circuit. For a motor branch circuit, the overcurrent protection is required for overcurrents due to short circuits and faults to ground only.

5.5 **BRANCH CIRCUIT PROTECTIVE DEVICE** – A fuse or circuit breaker that has been evaluated to a safety standard for providing overcurrent protection.

5.6 **CLASS 1 CIRCUIT** – A control circuit on the load side of overcurrent protective device where the voltage does not exceed 600 volts, and where the power available is not limited, or control circuit on the load side of power limiting supply, such as a transformer.

5.7 **CLASS 1 WIRING** – Conductors of a Class 1 Circuit.

5.8 **CLASS 2 CIRCUIT** – A control circuit supplied from a source having limited voltage (30 Vrms or less) and current capacity, such as from the secondary of a Class 2 transformer, and rated for use with Class 2 remote-control or signaling circuits.

5.9 **CLASS 2 WIRING** – Conductors of a Class 2 circuit.

5.10 **CONTROL CIRCUIT** – A circuit that carries the electric signals directing the performance of a controller, and which does not carry the main power circuit. A control circuit is, in most cases, limited to 15 amperes.

5.11 **CONTROL TRANSFORMER** – A transformer whose secondary supplies power to control circuit devices only (excluding loads).

5.12 **CONTROLLER** – A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

5.13 **COVER** – An unhinged portion of an enclosure that covers an opening.

5.14 DISCONNECT SWITCH – A device that disconnects all ungrounded conductors of a circuit from their electrical supply.

5.15 DOOR – A hinged portion of an enclosure that covers an opening.

5.16 EQUIPMENT – A general term, including fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, a modular data center.

5.17 EXIT ACCESS – Means that portion of an exit route that leads to an exit.

5.18 EXIT ROUTE – Means a continuous and unobstructed path of exit travel from any point within a workplace to a place of safety (including refuge areas). An exit route consists of three parts: The exit access; the exit; and, the exit discharge. (An exit route includes all vertical and horizontal areas along the route.)

5.19 FEEDER CIRCUIT – The conductors and circuitry on the supply side of the branch circuit overcurrent protective device.

5.20 FIELD WIRING – Conductors to be installed by others to connect the equipment to source(s) of supply, remote control devices, and loads.

5.21 FIELD WIRING TERMINAL – A terminal provided to terminate field wiring.

5.22 FUSE, BRANCH CIRCUIT TYPE – A fuse of Class CC, G, H, J, K, L, R, and T. These fuses are able to provide branch circuit protection.

5.23 FUSE, SUPPLEMENTARY TYPE – Miscellaneous type and miniature type fuses. These fuses are able to provide supplementary protection only.

5.24 GENERAL-USE RATING – A rating, expressed in volts and amperes, assigned to a device that is intended to control:

- a) A load with a continuous or inrush ampere rating not exceeding the ampere rating of the device;
- b) When ac rated, a load that has a power factor of 0.75 to 0.80 (inductive); and
- c) When dc rated, a load that is resistive (non-inductive).

5.25 INSTANTANEOUS TRIP CIRCUIT BREAKER – A circuit breaker in which no delay is introduced into the tripping action of the circuit breaker. These circuit breakers are able to provide branch circuit protection.

5.26 INVERSE-TIME CIRCUIT BREAKER – A circuit breaker in which a delay is introduced into the tripping action of the circuit breaker. The delay decreases as the magnitude of the current increases. These circuit breakers are able to provide branch circuit protection.

5.27 ISOLATED SECONDARY CIRCUIT – A circuit derived from an isolating source (such as a transformer, optical isolator, limiting impedance, or electro-mechanical relay) and having no direct connection back to the primary circuit (other than through the grounding means). A secondary circuit that has a direct connection back to the primary circuit is evaluated as part of the primary circuit.

5.28 LOW-VOLTAGE LIMITED ENERGY CIRCUIT – A control circuit involving a peak open-circuit potential of not more than 42.4 volts (dc or peak) supplied by a primary battery or by an isolated secondary circuit, and where the current capacity is limited by an overcurrent device, such as a fuse, or by the inherent capacity of the secondary transformer or power supply, or a combination of a secondary winding and an impedance. A circuit derived from a line-voltage circuit by connecting a resistance in series with the supply circuit to limit the voltage and current is not identified as a low-voltage limited energy circuit.

5.29 OVERCURRENT PROTECTION – A device designed to open a circuit when the current through it exceeds a predetermined value. The ampere rating of the device is selected for a circuit to terminate a condition where the current exceeds the rating of conductors and equipment due to overloads, short circuits and faults to ground.

5.30 OVERLOAD PROTECTION – Protection required for motor circuits that will operate to prohibit excessive heating due to running overloads and failure to start.

5.31 POWER CIRCUIT – Conductors and components of branch and feeder circuits.

5.32 POWER TRANSFORMER – A transformer whose secondary winding supplies power to loads or a combination of loads and control circuit devices operating at the secondary voltage.

5.33 SHORT CIRCUIT CURRENT RATING – The prospective symmetrical fault current at a nominal voltage to which an apparatus or system is able to be connected without sustaining damage exceeding the defined acceptance criteria.

5.34 SUPPLEMENTARY PROTECTION – A device intended to provide additional protection subsequent to branch circuit protection. They have not been evaluated for providing branch circuit protection.

5.35 SUPPLEMENTARY PROTECTOR – A manually resettable device designed to open the circuit automatically on a predetermined value of time versus current or voltage within an appliance or other electrical equipment. It is also able to be provided with manual means for opening or closing the circuit. These devices are able to provide supplementary protection only.

5.36 WIRE BENDING SPACE – The amount of space required between a field wiring terminal and an enclosure wall directly opposite the terminal, to provide enough space for field wiring conductors.

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6 Electrical

6.1 General

6.1.1 Electrical circuits that are an integral part of the MDC including lighting, control, power, HVAC (heating, ventilation and air-conditioning), emergency lighting, alarm circuits, and the like shall comply with the appropriate requirements for its use and installation and shall be certified and labeled.

6.1.2 Live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by approved enclosures or by location in a room, vault, or similar enclosure that is accessible only to qualified persons.

6.1.3 Access to energized parts shall be judged in accordance with Clause 2.1.1.1 of the Standard for Information Technology Equipment – Safety – Part 1: General Requirements UL 60950-1 or Clause 5.3.2, Accessibility to electrical energy sources and safeguards, of the Standard for Audio/Video, Information and Communication Technology Equipment - Part 1: Safety Requirements, UL 62368-1.

6.1.4 Electrical equipment rooms or enclosures housing electrical apparatus that are controlled by a lock(s) shall be considered accessible only to qualified persons.

6.1.5 Entrances to rooms and other guarded locations that contain exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

6.1.6 In a service access area, bare parts of AC or DC mains circuits, shall be located or guarded so that accidental shorting across opposite polarity, or to ground, SELV circuits or communications circuits, for example by tools or test probes used by service personnel, is unlikely. Parts in a Class 2 or limited power circuits need not be located or guarded from accidental contact by service personnel.

6.1.7 Electrical equipment that is located in areas subject to condensation, or the effects of condensation (e.g. dripping from chilled pipes or surfaces), shall be suitable for outdoor use or suitably protected against contact with water.

6.2 Electrical supply and distribution

6.2.1 Equipment used for the electrical supply and distribution in a modular data center including fittings, devices, luminaires, apparatus, machinery, and the like shall comply with the appropriate requirements for its use and installation and shall be certified and labeled.

6.2.2 Certified equipment shall be installed and used in accordance with any instructions or limitations included in the certification.

6.2.3 Premise transformers installed in the MDC area shall be of the dry type or type filled with a noncombustible dielectric medium. Such transformers shall be installed in accordance with the requirements of the National Electrical Code (NEC), NFPA 70.

6.2.4 Service entrance transformers shall not be permitted in an MDC.

Exception: Service entrance transformers shall be permitted in a separate module or structure intended to house only service entrance equipment and power distribution and control equipment for the MDC.

6.2.5 Protection against lightning surges shall be provided in accordance with the requirements of the National Electrical Code (NEC), NFPA 70.

6.2.6 Junction boxes shall be approved, completely enclosed, fastened, accessible, and grounded.

6.3 Wiring and protection

6.3.1 Wiring shall be suitable for its use and installation and shall be certified. This requirement does not apply to wiring that is part of certified equipment.

6.3.2 Wiring and wiring protection shall comply with Chapter 2 of the National Electrical Code (NEC), NFPA 70.

6.4 Wiring methods and materials

6.4.1 Wiring methods and materials shall comply with Chapter 3 of the National Electrical Code (NEC), NFPA 70.

6.4.2 The following wiring methods are not permitted:

- a) Integrated Gas Spacer Cable: Type IGS [Article 326 of the National Electrical Code (NEC), NFPA 70]
- b) Concealed Knob-and-Tube Wiring (Article 394 of the NEC)
- c) Messenger-Supported Wiring (Article 396 of the NEC)
- d) Open Wiring on Insulators (Article 398 of the NEC)
- e) Outdoor Overhead Conductors over 600 Volts (Article 399 of the NEC)

6.5 Field wiring compartments

6.5.1 A field-wiring compartment in which branch circuit connections are to be made shall:

- a) Permit the connection of the supply wires after the MDC is installed;
- b) Permit the connection to be introduced and connected easily; and
- c) Be located so that the connections may be readily inspected after the MDC is installed.

6.5.2 An outlet box, terminal box, wiring compartment, or similar component, in which connections to the MDC are made in the field shall be free from any sharp edge including screw threads, a burr, a fin, a moving part, or similar component that may abrade the insulation on conductors, or otherwise damage the wiring.

6.5.3 The outlet box, terminal box, wiring compartment, or similar component, in which connections to the MDC are made in the field shall comply with the applicable requirements in the:

- a) Standard for Metallic Outlet Boxes, UL 514A;
- b) Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers, UL 514C; or
- c) Standard for Enclosures for Electrical Equipment, UL 50.

6.5.4 The wiring compartment for the supply connections shall not occupy the same space for any of the Class 2, communications or other low voltage or signal wiring.

6.6 Field Wiring Terminals

6.6.1 General

6.6.1.1 A terminal, such as a pressure wire connector or wire-binding screw, shall be provided for connection of each conductor intended to be installed in the MDC in the field.

6.6.1.2 A field wiring terminal shall be located so that:

- a) It is accessible for examination and
- b) Connection is able to be tightened or wires removed without loosening any screws that secure internal (factory) wiring, bus bars, or components (such as circuit breakers, switches, and fuseholders).

6.6.1.3 A field wiring terminal shall be for use with copper or aluminum conductors or both and marked in accordance with 6.6.1.4.

6.6.1.4 All field-wiring terminals shall be marked with one of the following:

- a) "Use Copper Conductors Only" for terminals intended for connection only to copper wire;
- b) "Use Aluminum Conductors Only" for terminals evaluated only for connection to aluminum wire;
- c) "Use Copper or Aluminum Conductors" or "Use Copper, Copper-Clad Aluminum, or Aluminum Conductors" for terminals evaluated for either copper or aluminum wire; or
- d) "Use Copper or Copper-Clad Aluminum Conductors" for terminals evaluated for connection to either copper or copper-clad aluminum wire.

6.6.2 Component requirements

6.6.2.1 A pressure wire connector of a terminal block shall comply with the requirements contained in the Standard for Terminal Blocks, UL 1059. In addition a terminal block shall:

- a) Have electrical spacings that comply with the Standard for Industrial Control Panels, UL 508A, Section 10, Spacings and
- b) Have been investigated for connection of field wiring.

6.6.2.2 A pressure wire connector of a component other than a terminal block shall:

- a) Comply with the requirements in the Standard for Wire Connectors, UL 486A-486B or the Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors, UL 486E; and
- b) Have electrical spacings at field wiring terminals that comply with the Standard for Industrial Control Panels, UL 508A, Section 10, Spacings.

6.6.2.3 A wire binding screw, other than one on a terminal block or a component, shall comply with the following:

- a) A terminal plate tapped for a wire-binding screw shall be of metal not less than 0.030 inch (0.76 mm) thick for a 14 AWG (2.1 mm²) or smaller wire, and not less than 0.050 inch (1.27 mm) thick for a wire larger than 14 AWG (2.1 mm²). There shall be at least two full threads in the plate; and

Exception: Two full threads are not required if fewer threads result in a secure connection in which the threads will not strip upon application of a 20 pound-inch (2.3 N-m) tightening torque.

- b) A terminal plate formed from stock having the required thickness specified in (a) is able to have the metal extruded at the tapped hole for the binding screw to provide two full threads; and
- c) A wire-binding screw shall thread into metal; and
- d) A wire-binding screw shall be No. 8 (4.2 mm diameter) or larger screw for securing a 10 AWG (5.3 mm²) or smaller conductor, or a No. 6 (3.5 mm diameter) screw for securing a 14 AWG (2.1 mm²) conductor only.

6.6.2.4 A power distribution block shall comply with the requirements contained in:

- a) The Outline of Investigation for Power Distribution Blocks, Subject 1953, for use in branch or feeder circuits or
- b) 6.6.2.1.

6.6.3 Sizing

6.6.3.1 The required size of the field wiring terminal shall not be less than 14 AWG (2.1 mm²) and shall be determined by:

- a) Calculating the required ampacity per 6.6.3.2 – 6.6.3.6; and
- b) Determining the minimum field wiring conductor size from Table 6.1 having a corresponding ampacity that is equal to or greater than the required ampacity from (a).

Table 6.1
Ampacities of insulated conductors

Wire size		60°C (140°F)		75°C (167°F)	
AWG	(mm ²)	Copper	Aluminum	Copper	Aluminum
14	(2.1)	15	—	15	—
12	(3.3)	20	15	20	15
10	(5.3)	30	25	30	25
8	(8.4)	40	30	50	40
6	(13.3)	55	40	65	50
4	(21.2)	70	55	85	65
3	(26.7)	85	65	100	75
2	(33.6)	95	75	115	90
1	(42.4)	110	85	130	100
1/0	(53.5)	—	—	150	120
2/0	(67.4)	—	—	175	135
3/0	(85.0)	—	—	200	155
4/0	(107.2)	—	—	230	180
250 kcmil	(127)	—	—	255	205
300	(152)	—	—	285	230
350	(177)	—	—	310	250
400	(203)	—	—	335	270
500	(253)	—	—	380	310
600	(304)	—	—	420	340
700	(355)	—	—	460	375
750	(380)	—	—	475	385
800	(405)	—	—	490	395
900	(456)	—	—	520	425
1000	(506)	—	—	545	445
1250	(633)	—	—	590	485
1500	(760)	—	—	625	520
1750	(887)	—	—	650	545
2000	(1013)	—	—	665	560

NOTES –

1 For multiple-conductors of the same size (1/0 AWG or larger) at a terminal, the ampacity is equal to the value in this table for that conductor multiplied by the number of conductors that the terminal is able to accommodate.

2 These values of ampacity apply only when not more than three conductors are intended to be field-installed in the conduit. When four or more conductors, other than a neutral that carries the unbalanced current, are intended to be installed in a conduit (occurring because of the number of conduit hubs provided in outdoor equipment, the number of wires necessary in certain polyphase systems, or other reasons), the ampacity of each of the conductors is: 80 percent of these values if 4 – 6 conductors are involved, 70 percent of these values if 7 – 24 conductors, 60 percent of these values if 25 – 42 conductors, and 50 percent of these values if 43 or more conductors.

6.6.3.2 For motors, fixed electrical space heating equipment and lighting loads, the anticipated field wiring shall have an ampacity of 125 percent of the full-load current rating of the load involved.

Exception No. 1: A terminal of a component with a marked horsepower rating, such as a motor starter, is determined to be capable of retaining field wiring having an ampacity of 125 percent of the full-load current corresponding to the horsepower rating from Table 6.3.

Exception No. 2: A terminal for connection of a heater load provided with individual branch circuit protection that is greater than 125 percent of the heater current, shall be capable of retaining field wiring having an ampacity not less than the rating of the branch circuit protective device.

6.6.3.3 For terminals intended to carry current from a combination of one or more motors, or one motor and one or more other loads, the field wiring shall have an ampacity of 125 percent of the largest motor full-load amperes of the group plus 100 percent of all remaining loads.

6.6.3.4 For terminals intended to carry current from a dc motor load operating from a rectified single phase power supply (not a variable-speed drive or speed control), the field wiring shall have an ampacity of:

- a) 190 percent of the full-load motor current where a rectifier bridge of the single phase half-wave type is used or
- b) 150 percent of the full-load motor current where a rectifier bridge of the single phase full-wave type is used.

6.6.3.5 For terminals that will carry the input current to power conversion equipment or a solid-state motor speed controller in which the input current is different from the motor full-load current, the field wiring shall have an ampacity of 125 percent of the input current rating of the device.

6.6.3.6 For terminals intended to carry the load current from a wye-delta starter, the ampacity of the field wiring shall be:

- a) In accordance with 6.6.3.2 and
- b) Based on a load current equal to 58 percent of the motor full-load current.

6.7 Wire bending space

6.7.1 The distance between the end of a pressure wire connector or terminal block for connection of a field installed wire, and the wall of the enclosure toward which the wire is to be directed, shall not be less than that indicated in Table 6.2.

Table 6.2
Wire bending space at field wiring terminals

Size of wire AWG or MCM (mm ²)		Minimum bending space, terminal to wall, inches (mm)			
		Wires per terminal ^a			
		1	2	3	4 or more
14 – 10	(2.1 – 5.3)	Not specified	a	a	a
8 – 6	(8.4 – 13.3)	1-1/2 (38)	a	a	a
4 – 3	(21.2 – 26.7)	2 (51)	a	a	a
2	(33.6)	2-1/2 (64)	a	a	a
1	(42.4)	3 (76)	a	a	a
1/0	(53.5)	5 (127)	5 (127)	7 (178)	—
2/0	(67.4)	6 (152)	6 (152)	7-1/2 (191)	—
3/0	(85.0)	7 (178)	7 (178)	8 (203)	—
4/0	(107.2)	7 (178)	7 (178)	8-1/2 (216)	—
250	(127)	8 (203)	8 (203)	9 (229)	10 (254)
300	(152)	10 (254)	10 (254)	11 (279)	12 (305)
350	(177)	12 (305)	12 (305)	13 (330)	14 (356)
400	(203)	12 (305)	12 (305)	14 (356)	15 (381)
500	(253)	12 (305)	12 (305)	15 (381)	16 (406)
600	(304)	14 (356)	16 (406)	18 (457)	19 (483)
700	(355)	14 (356)	16 (406)	20 (508)	22 (559)
750 – 800	(380 – 405)	18 (457)	19 (483)	22 (559)	24 (610)
900	(456)	18 (457)	19 (483)	24 (610)	24 (610)
1000	(506)	20 (508)	—	—	—
1250	(633)	22 (559)	—	—	—
1500 – 2000	(760 – 1013)	24 (610)	—	—	—

NOTE: "—" indicates no value established

^a Conductors smaller than 1/0 AWG shall not be connected in parallel.

6.7.2 Upon leaving the lug or connector, the distance specified in Table 6.2 shall be measured in a straight line from the center of the opening in the connector, in the direction in which the wire leaves the terminal, perpendicular to the enclosure wall.

6.7.3 When a wire is restricted by barriers or other means from being bent where it leaves the connector, the distance required by Table 6.2 shall be measured from the end of the barrier.

6.7.4 The required bending space is dependent on the size of the anticipated field wire to be connected to the connector or terminal in accordance with Section 6.6, Field Wiring Terminals.

6.8 Flexible cable

6.8.1 Flexible cable may only be used for connections between enclosures of an MDC system that is certified as a system. Flexible cords or cables shall not be used for connection to the branch circuit or electrical service.

NOTE: For example, flexible cords may be used between an MDC enclosure containing only servers and one containing power distribution equipment.

6.8.2 Where flexible cords or cables are used, they shall be suitable for extra-hard usage. Where used outdoors, flexible cords and cables shall also be suitable for wet locations and shall be sunlight resistant. Extra-hard usage flexible cords or cables shall be permitted for use as permanent wiring between MDC enclosures only where not subject to physical damage.

6.8.3 Single-conductor cable shall be permitted only in sizes 2 AWG or larger.

6.8.4 Open conductors are prohibited except as part of a certified assembly or festoon lighting installed in accordance with the National Electrical Code (NEC), NFPA 70, Article 225.

6.8.5 Flexible cords or cables shall be continuous without splice or tap between boxes or fittings.

6.9 Separation of circuits

6.9.1 General

6.9.1.1 Wiring and connections shall be routed, enclosed, secured, etc. to comply with the separation of circuits as required by the National Electrical Code (NEC), NFPA 70.

Note: See 770.133 of the NEC for Optical Fiber Cables, 800.133 of the NEC for Communications Cables, 810.18 and 810.70 of the NEC for Antenna Lead-In Conductors, 820.133 of the NEC for Coaxial Cables, and 830.133 of the NEC for Network Powered Broadband Communications Cables.

6.9.1.2 Where permitted by the National Electrical Code (NEC), NFPA 70, cables and connectors containing different circuits may not require separation in an enclosure, raceway or wiring compartment provided that they are suitable for the highest class of circuit involved.

6.9.2 Separation of circuits in field wiring compartments

6.9.2.1 Field wiring compartments shall be constructed to accommodate the separation of circuits as required by the National Electrical Code, NFPA 70.

6.9.2.2 Field-wiring terminals and external circuit connectors for Class 2, Class 3, or communication cables shall not be in a wiring compartment, box, or other area with conductors or terminals for other circuits. Field installed conductors shall be secured so that they cannot contact uninsulated live parts, field-installed wiring, and factory installed wiring of any other circuit.

Exception No. 1: This requirement does not apply if a solid (unpierced) partition, permanently secured in place, is provided to separate field-installed conductors from field- and factory-installed conductors and live parts of any other circuit.

Exception No. 2: In units for which field connections for some applications are different from the connections for other applications, a removable solid partition or a permanent partition in which there are holes for the passage of conductors may be used. Instructions for use of a removable or pierced partition are to be a permanent part of the unit.

Exception No. 3: Instead of a partition, a wiring diagram may be provided on or with the unit if provision is made for routing all conductors, if such routing is clearly and completely shown by the diagram, and if complete wiring instructions accompany the diagram.

Exception No. 4: Separation of some field-installed conductors from others and from uninsulated live parts connected to different circuits can be accomplished by arranging the location of openings in the enclosure for the various conductors (with respect to the terminals or other uninsulated live parts) so that there is no likelihood that the conductors or parts of different circuits can be intermingled. If no more openings than are necessary are provided in the enclosure for wiring of the unit and each opening is opposite a set of terminals, it is to be assumed in determining compliance with the requirement for the separation of terminals that conductors entering the enclosure through any such opening will be connected only to the terminals opposite that opening. If more openings than are necessary are provided in the enclosure for wiring the unit, it is to be assumed in determining compliance with the requirement for the separation of terminals that conductors will enter the enclosure through openings that are not opposite the terminals to which they are intended to be connected and will touch insulated conductor and uninsulated live parts of circuits other than their own.

6.9.2.3 In determining whether a unit complies with these requirements the unit is to be wired in the manner in which it would be wired in the field. A reasonable amount of slack is to be left in each conductor within the enclosure, and not more than average care is to be used in stowing the slack in the compartment.

6.9.2.4 Where permitted by the National Electrical Code (NEC), NFPA 70, cables containing different circuits may not require separation in an enclosure or wiring compartment provided that all cables are suitable for the highest class of circuit involved. If this provision in the NEC is required to comply with the separation of circuits criteria, a marking shall be provided adjacent to the wiring terminals indicating that all field wired cables are to comply with the requirements for highest class circuit involved.

6.10 Disconnecting means

6.10.1 An approved means shall be provided to disconnect power to all electronic equipment in the MDC or in designated zones within the MDC. There shall also be a similar approved means to disconnect the power to all dedicated HVAC systems serving the room or designated zones and shall cause all required fire/smoke dampers to close. The control for these disconnecting means shall be grouped and identified and shall be readily accessible at the principal exit doors. A single means to control both the electronic equipment and HVAC systems in the room or in a zone shall be permitted. Where a pushbutton is used as a means to disconnect power, pushing the button in shall disconnect the power. Where multiple zones are created, each zone shall have an approved means to confine fire or products of combustion to within the zone. Installations complying with NFPA 70, National Electrical Code, Article 685, are permitted.

6.10.2 Except for installations and constructions covered in (a) or (b), UPS systems installed as part of an MDC, and their supply and output circuits, shall comply with 6.10.1. The disconnecting means shall also electrically disconnect the energy storage mechanism (battery, flywheel, etc.) from its load.

a) Installations qualifying under the provisions of the National Electrical Code (NEC), NFPA 70, National Electrical Code, Article 685

b) Power sources limited to 750 volt-amperes or less derived either from UPS equipment or from battery or other storage circuits integral to electronic equipment.

6.10.3 A disconnect switch shall open each ungrounded conductor of each incoming supply circuit, service or feeder, where permitted. The main disconnecting means shall be marked as suitable for use as service equipment. If multiple circuits are supplied to the MDC and not located at the same location, permanent plaques must be installed identifying each disconnect location and the area served by each.

6.10.4 If the handle of a main disconnect switch is operated vertical rather than rotationally or horizontally, the up position of the handle shall be the "on" position.

6.10.5 Application of kits and mounting of the unit shall be in accordance with instruction sheets provided by switch manufacturer.

6.10.6 Circuit Breaker – These devices may be used for controlling motors, other equipment, or a combination thereof up to 80 percent of their ampere rating. The total load shall be defined as the full load current of all motors and other loads that may be energized at one time. Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits shall be certified and shall be marked SWD or HID. Circuit breakers used as switches in high-intensity discharge lighting circuits shall be certified and shall be marked as HID.

6.10.7 Molded Case Switch – Same as circuit breaker except may control 100 percent of its rating.

6.10.8 Miscellaneous Switch With Ampere Rating Only – This device may not be used for controlling motor loads. It may be used controlling other loads where the switch is rated not less than 115 percent of the total load rating.

6.10.9 Miscellaneous Switch With Horsepower Rating – This device may be used for controlling motors, other equipment, or a combination thereof when the switch rating is not less than 100 percent of the full load rating of all non-motor equipment plus 115 percent of the load rating as determined by converting motor ratings to full load ampere ratings per the National Electrical Code (NEC), NFPA 70, Tables 430.248 and 430.250 or as shown in Table 6.3 in this Outline for motor full load ampere ratings.

6.10.10 Miscellaneous Switch With Horsepower Only Rating – This device may be used for controlling motors only, and is used as indicated in 6.10.9, based on not exceeding the hp rating of the switch.

6.10.11 Indicator – The disconnecting means shall have an indicator which shows whether it is in the open (off) or closed (on) position.

6.10.12 Handle – The operating handle shall be arranged such that it can be locked in the “off” or “open” position. The provision for locking the disconnecting means shall remain in place with or without the lock installed. The operating portion of the handle shall not be more than 2.0 m (6-1/2 ft.) above the floor.

6.11 Service equipment – services rated 600 V or less

6.11.1 For an MDC that is designed such that it may be powered from a separate electrical service, the service equipment for control and protection of services and their installation shall comply with Article 230 of the National Electrical Code (NEC), NFPA 70. The service equipment and their arrangement and installation shall permit the installation of the service entrance conductors in accordance with Article 230 of the NEC.

6.11.2 Service equipment rated at 600 Volts or less shall be certified and marked as being suitable for use as service equipment.

6.11.3 Where raceways for service-entrance conductors are exposed to the weather, they shall be suitable for use in wet locations and have provisions for drainage.

6.11.4 Service disconnects shall be operable without exposing the operator to uninsulated live parts.

6.11.5 No equipment shall be connected to the supply side of the service disconnecting means, except as permitted in Paragraph 230.82 of the National Electrical Code (NEC), NFPA 70.

6.11.6 Electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and the like that are may require servicing or maintenance while energized shall be marked to warn about potential electric arc flash hazards. The marking shall be clearly visible to qualified persons prior to examination, adjustment, servicing, or maintenance of the equipment.

Note 1: NFPA 70E, Standard for Electrical Safety in the Workplace, provides assistance in determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

Note 2: ANSI Z535.4, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products.

6.12 Panelboards and switchboards

6.12.1 A panelboard of the deadfront type shall be installed in each MDC. Electrical feeder and branch circuits shall be supplied from panelboards that comply with the requirements in the Standard for Panelboards, UL 67, or switchboards that comply with the requirements in the Standard for Switchboards, UL 891. All panelboards and switchboards shall be provided with markings specified in Markings, Section 19.

6.12.2 A main disconnecting means shall be provided where fuses are used or where two or more circuit breakers are used. A main overcurrent protective device shall be rated not higher than the panelboard rating.

6.12.3 All switchboards, panelboards, and the like shall be located in dedicated spaces and protected from damage.

6.12.4 The space equal to the width and depth of the equipment and extending from the floor to a height of 1.8 m (6 ft.) above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation. No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this zone.

6.12.5 A panelboard shall be:

- a) Readily accessible; and
- b) In a location where condensation is not likely to occur.

6.12.6 Where circuit breakers or fuses are applied in compliance with the series combination ratings marked on the equipment by the manufacturer, the equipment enclosure(s) shall be legibly marked in the field to indicate the equipment has been applied with a series combination rating. The marking shall be readily visible and state the following:

CAUTION – SERIES COMBINATION SYSTEM RATED ____ AMPERES. IDENTIFIED REPLACEMENT COMPONENTS REQUIRED.

6.12.7 Where a panelboard or switchboard supplies continuous loads or a combination of continuous and non-continuous loads, the rating of the panelboard or switchboard shall be not less than 125 percent of the continuous load plus 100 percent of the non-continuous load. The total load used to determine the minimum ratings of the panelboard or switchboard, and main circuit breaker, shall be the sum of all the following:

- a) Lighting loads are calculated based on 2 VA per ft², or the actual connected load, whichever is larger, in VA. This figure divided by the supply voltage represents amperes per phase.
- b) Receptacle outlet loads are calculated by multiplying the number of receptacles by 180 VA, then dividing this by the supply voltage to obtain amperes. Multiple receptacles consisting of four or more receptacles on the same yoke shall be computed as not less than 90 VA per receptacle. Where a receptacle is supplied by a dedicated branch circuit for connection of stationary equipment, the actual load current should be used instead of the 180 VA factor.

c) Other than for motors built for low speeds (less than 1200 RPM) or high torques, and for multispeed motors, the values given in Tables 6.3 and 6.4 shall be used for motor loads. Motors built for low speeds (less than 1200 RPM) or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

d) 25 percent of the largest motor rating in (c).

e) The nameplate current rating of heating loads shall be used. For non-coincident loads (such as heating and air conditioning), the larger load is to be used in this calculation.

f) The rated current for any other circuits connected to the panelboard (such as the control circuits of installed equipment).

Table 6.3
Full-load motor-running currents in amperes corresponding to various AC horsepower ratings

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts ^a		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
1/10	3.0	–	–	–	–	–	1.5	–	1.0	–	–	–	–	–
1/8	3.8	–	–	–	–	–	1.9	–	1.2	–	–	–	–	–
1/6	4.4	–	2.5	–	2.4	–	2.2	–	1.4	–	–	–	–	–
1/4	5.8	–	3.3	–	3.2	–	2.9	–	1.8	–	–	–	–	–
1/3	7.2	–	4.1	–	4.0	–	3.6	–	2.3	–	–	–	–	–
1/2	9.8	4.4	5.6	2.5	5.4	2.4	4.9	2.2	3.2	1.3	2.5	1.1	2.0	0.9
3/4	13.8	6.4	7.9	3.7	7.6	3.5	6.9	3.2	4.5	1.8	3.5	1.6	2.8	1.3
1	16.0	8.4	9.2	4.8	8.8	4.6	8.0	4.2	5.1	2.3	4.0	2.1	3.2	1.7
1-1/2	20.0	12.0	11.5	6.9	11.0	6.6	10.0	6.0	6.4	3.3	5.0	3.0	4.0	2.4
2	24.0	13.6	13.8	7.8	13.2	7.5	12.0	6.8	7.7	4.3	6.0	3.4	4.8	2.7
3	34.0	19.2	19.6	11.0	18.7	10.6	17.0	9.6	10.9	6.1	8.5	4.8	6.8	3.9
5	56.0	30.4	32.2	17.5	30.8	16.7	28.0	15.2	17.9	9.7	14.0	7.6	11.2	6.1
7-1/2	80.0	44.0	46.0	25.3	44.0	24.2	40.0	22.0	27.0	14.0	21.0	11.0	16.0	9.0
10	100.0	56.0	57.5	32.2	55.0	30.8	50.0	28.0	33.0	18.0	26.0	14.0	20.0	11.0
15	135.0	84.0	–	48.3	–	46.2	68.0	42.0	44.0	27.0	34.0	21.0	27.0	17.0
20	–	108.0	–	62.1	–	59.4	88.0	54.0	56.0	34.0	44.0	27.0	35.0	22.0
25	–	136.0	–	78.2	–	74.8	110.0	68.0	70.0	44.0	55.0	34.0	44.0	27.0
30	–	160.0	–	92	–	88	136.0	80.0	87.0	51.0	68.0	40.0	54.0	32.0
40	–	208.0	–	120	–	114	176.0	104.0	112.0	66.0	88.0	52.0	70.0	41.0
50	–	260.0	–	150	–	143	216.0	130.0	139.0	83.0	108.0	65.0	86.0	52.0
60	–	–	–	177	–	169	–	154.0	–	103.0	–	77.0	–	62.0
75	–	–	–	221	–	211	–	192.0	–	128.0	–	96.0	–	77.0
100	–	–	–	285	–	273	–	248.0	–	165.0	–	124.0	–	99.0
125	–	–	–	359	–	343	–	312.0	–	208.0	–	156.0	–	125.0
150	–	–	–	414	–	396	–	360.0	–	240.0	–	180.0	–	144.0
200	–	–	–	552	–	528	–	480.0	–	320.0	–	240.0	–	192.0
250	–	–	–	–	–	–	–	604	–	403.0	–	302.0	–	242.0
300	–	–	–	–	–	–	–	722	–	482.0	–	361.0	–	289.0
350	–	–	–	–	–	–	–	828	–	560.0	–	414.0	–	336.0
400	–	–	–	–	–	–	–	954	–	636.0	–	477.0	–	382.0
450	–	–	–	–	–	–	–	1030	–	–	–	515	–	412

Table 6.3 Continued

Horse power	110 – 120 Volts		200 Volts		208 Volts		220 – 240 Volts ^a		380 – 415 Volts		440 – 480 Volts		550 – 600 Volts	
	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase	Single phase	Three phase
500	–	–	–	–	–	–	–	1180	–	786.0	–	590.0	–	472.0

^a To obtain full-load currents for 265 and 277 volt motors, decrease corresponding 220 – 240 volt ratings by 13 and 17 percent, respectively.

Table 6.4

Full-load motor-running currents in amperes corresponding to various DC horsepower ratings

Horsepower	90 volts	110 – 120 volts	180 volts	220 – 240 volts	500 volts	550 – 600 volts
1/10	–	2.0	–	1.0	–	–
1/8	–	2.2	–	1.1	–	–
1/6	–	2.4	–	1.2	–	–
1/4 ^a	4.0	3.1	2.0	1.6	–	–
1/3	5.2	4.1	2.6	2.0	–	–
1/2	6.8	5.4	3.4	2.7	–	–
3/4	9.6	7.6	4.8	3.8	–	1.6
1	12.2	9.5	6.1	4.7	–	2.0
1-1/2	–	13.2	8.3	6.6	–	2.7
2	–	17	10.8	8.5	–	3.6
3	–	25	16	12.2	–	5.2
5	–	40	27	20	–	8.3
7-1/2	–	58	–	29	13.6	12.2
10	–	76	–	38	18	16
15	–	110	–	55	27	24
20	–	148	–	72	34	31
25	–	184	–	89	43	38
30	–	220	–	106	51	46
40	–	292	–	140	67	61
50	–	360	–	173	83	75
60	–	–	–	206	99	90
75	–	–	–	255	123	111
100	–	–	–	341	164	148
125	–	–	–	425	205	185
150	–	–	–	506	246	222
200	–	–	–	675	330	294

^a The full-load current for a 1/4-horsepower, 32-volt dc motor is 8.6 amperes.

6.12.8 Individual circuit breaker ratings shall not be less than 125 percent of the continuous load, plus 100 percent of the non-continuous load of the circuit.