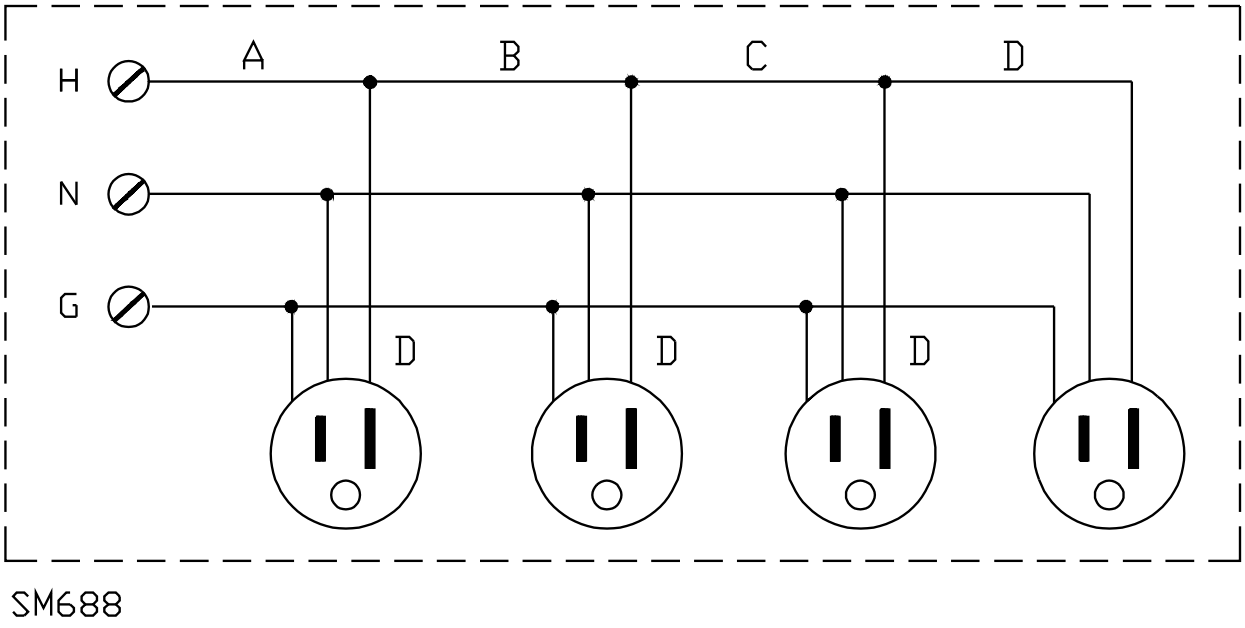
Figure 18.5
Illustrative example of requirements in 18.3.2



Circuit rating: 20 A

Current rating associated with blade and pin configuration of receptacles: 15 A

Receptacles each marked as specified in 59.2 for an intended maximum available current of 5 A.

Load current value assignment	
Component	**Load current value used**
Each receptacle	5 A

Conductor size determination		
Conductor letter code	**Load current value**	**Minimum size of conductor without temperature test**
A	20 A	12 AWG
B	15 A	14 AWG
C	10 A	14 AWG
D	5 A	18 AWG

19 Receptacles, Drop Cords, Cord Connectors, Interconnecting Flexible Cords and Cables, and Overcurrent Protection

19.1 A drop cord shall consist of one of the types of flexible cord or cable identified in 26.3(a) and shall terminate in a cord connector.

19.2 External wiring used to interconnect separated assemblies of a product, such as a luminaire and a remote ballast assembly or remote control assembly, shall be flexible cord or cable of the type identified in 26.3(a), or equivalent.

Exception: External wiring connected to a Class 2 circuit or a limited-voltage/current circuit is not required to be flexible cord or cable.

19.3 The slot or pin configuration of a standard receptacle or cord connector shall be that associated with the voltage of the circuit to which the receptacle or cord connector is connected.

19.4 A non-standard receptacle or cord connector shall be supplied by a circuit with a voltage rating not exceeding the voltage rating of the receptacle or cord connector being used.

19.5 All receptacles and cord connectors shall be of a grounding type.

Exception: A receptacle or cord connector is not required to be of a grounding type when the circuit supplying the receptacle or cord connector is rated 150 volts DC or less and the product is marked as specified in 56.2 to indicate that the product is intended for use only in motion picture and television studios and similar locations.

19.6 A receptacle or cord connector shall be provided with overcurrent protection that is an integral part of the equipment when the situation described in (a) or (b) applies.

a) The receptacle or cord connector is supplied by the secondary of a transformer that is part of the equipment.

b) A branch circuit to which the equipment is intended to be connected supplies the receptacle or cord connector in the equipment and is provided with overcurrent protection greater than the current rating associated with the slot or pin configuration of the receptacle or cord connector.

The overcurrent protection shall be of the branch-circuit type and shall not be greater than the current rating associated with the blade or pin configuration of the receptacle or cord connector.

Exception: A 15-ampere receptacle or cord connector supplied by a circuit that is protected by branch-circuit overcurrent protection rated 20 amperes is not required to be provided with additional overcurrent protection.

19.7 A user-serviceable fuse shall be mounted or guarded so that no live parts are exposed to unintentional contact. The arrangement shall be such that, at any time during replacement, the fuse is not gripped or held by any part of the fuseholder while live parts are exposed.

19.8 A clip for a cartridge fuse shall be mounted securely, resistant to turning, and provided with end stops.

19.9 Where markings or other manufacturer provided information associates a receptacle or connector with the Class 2 circuit classification, the receptacle or connector shall not be connected within the product to other than a circuit of either (a), (b), or (c).

a) A Class 2 circuit as defined in 3.6;

b) A limited-voltage/current circuit as defined in 3.32; or

c) An internal circuit not conductively connected to another source of voltage or current (the voltage or current is received through the receptacle or connector), and the circuit and its components comply with applicable requirements of this standard for separation from other than Class 2 and limited-voltage/current circuits.

For such a receptacle or connector, the marking in 57.7 shall be provided.

19.10 Where markings or other manufacturer provided information associates a receptacle or connector with the Class 3 circuit classification, the receptacle or connector shall not be connected within the product to other than a Class 3 circuit as defined in 3.8. For such a receptacle or connector, the marking in 57.8 shall be provided.

20 Polarity

20.1 Equipment containing a receptacle, cord connector, or a screw-shell type lampholder shall be wired such that a wire connected to the shell or to the grounded (neutral) terminal of the receptacle or cord connector is clearly identified for the connection of the grounded conductor of the supply circuit at the point of connection to the supply.

Exception: The polarity is not required to be marked when:

a) The lampholder or receptacle is connected to a circuit electrically-isolated from the supply (such as in the secondary of an isolated secondary transformer);

b) The lampholder or receptacle operates at a potential to ground and between conductors of 30 volts (42.4 volts peak) or less; or

c) The lampholder has a screw-shell lampholder that does not connect any pole of the supply to the shell until the lamp is nearly fully inserted, and which fully shrouds the metallic screw base of the lamp when contact is made.

20.2 A switch that de-energizes a lampholder shall disconnect all ungrounded conductors to the lampholder. It is to be assumed both conductors to a lampholder are ungrounded conductors when the equipment is not marked as specified in 55.2 for connection to an alternating current supply only.

Exception: This requirement does not apply to a switch that de-energizes a lampholder covered by the Exception to 20.1.

20.3 A terminal intended for the connection of a grounded supply conductor shall be either:

a) Made of or plated with metal that is white in color and shall be readily distinguishable from the other terminal or

b) Identified clearly in some other manner, such as on an attached wiring diagram.

20.4 A lead intended for the connection of a grounded power-supply conductor shall be finished to show a white or gray color and shall be readily distinguishable from the other leads.

20.5 The lead or terminal of a product with a ballast that is intended to be connected to a branch circuit with a grounded circuit conductor (neutral) shall be identified as such in accordance with the applicable requirements of 20.3 and 20.4.

21 Ballasts and Capacitors

21.1 A ballast and starter or ignitor, when provided, shall be rated for the operation of the type and size of lamps involved and shall be electrically connected in accordance with the diagram or instructions on or with the ballast.

21.2 A product having a capacitor as a component separate from the ballast shall incorporate means, such as a bleeder resistor or a construction as described in 21.4, for the automatic discharge of the capacitor within one minute after removal of the lamp from the circuit or after opening of the primary circuit, or both. The voltage (V) at the end of one minute across the terminals shall be reduced to a value of 50 volts or less, and the energy stored (J) shall be less than 20 joules as determined by the equation:

$$J = 5 \times 10^{-7} CV^2$$

in which:

C is the capacitor rating in microfarads.

21.3 To comply with 21.2, the maximum resistance value of a bleeder resistor shall be determined by the equation:

$$R = \frac{K}{C}$$

in which:

R is the resistance value in megohms;

K is the resistor factor determined in Table 21.1; and

C is the capacitor rating in microfarads.

Table 21.1
Bleeder resistor factor (k)

Voltage, peak	Voltage, (rms)[a]	Factor (k)
0 – 100	0 – 70	85
101 – 110	71 – 78	76
111 – 120	79 – 85	70
121 – 130	86 – 92	63
131 – 140	93 – 99	55
141 – 150	100 – 106	54
151 – 170	107 – 120	50
171 – 200	121 – 141	44
201 – 240	142 – 169	39
241 – 280	170 – 197	35
281 – 325	198 – 230	32
326 – 375	231 – 265	30
376 – 450	266 – 318	27
451 – 500	319 – 353	26
501 – 700	354 – 495	23
701 – 1000	496 – 707	19

[a] For a transformer-type ballast, the voltage value to be applied from this table is the rms voltage rating of the capacitor as specified by the ballast.

21.4 Compliance with the requirement in 21.2 is also achieved without the use of a bleeder resistor when the capacitor is located in a closed loop of the circuit and when the loop is not opened by removal of the lamp or by the opening of a switch, fuse, or similar device.

21.5 A capacitor or EMI filter connected across the primary circuit shall comply with the requirements in the Standard for Fixed Capacitors for Use in Electronic Equipment – Part 14: Sectional Specification: Fixed Capacitors for Electromagnetic Interference Suppression and Connection to the Supply Mains, UL 60384-14, or the Standard for Electromagnetic Interference Filters, UL 1283. A capacitor or EMI filter is determined to be across the primary circuit when, in a shorted condition, a current of greater than 1 ampere passes through it when the equipment is in a heated condition. The means used to limit the current to 1 ampere or less shall be a fixed impedance or a protective device rated 1 ampere or less.

21.6 An electrolytic capacitor located in unlimited power circuitry and that is greater than 10 mm (0.4 inch) in diameter shall be provided with a means for relieving internal pressure.

21.7 When an oil-filled capacitor in an electric discharge product is not integral with the ballast, its characteristics and installation shall comply with 21.8 – 21.11.

21.8 The capacitor shall comply with the Standard for Capacitors, UL 810, and shall be rated for the voltage to which it is to be connected. Such capacitors relieve an internal fault condition by movement of the terminal end of the capacitor enclosure to break the circuit internally. Movement is initiated by internal pressure during a fault condition, causing expansion of the capacitor body.

21.9 The capacitor shall be rated not less than the maximum fault current to which it is subjected, as follows:

a) A value of 10,000 amperes when connected across the ballast primary; that is, when the capacitor is in parallel with the ballast input circuit;

b) A value of 200 amperes when connected in series with a ballast coil; or

c) The maximum current available to the capacitor under capacitor short-circuit condition, as determined by an investigation.

21.10 The placement and mounting of a capacitor in a product shall be such that a free air space is provided in front of the capacitor end-terminals to enable the capacitor to expand, without obstruction, under a fault condition. This expansion clearance space shall allow the front enclosure and terminals of the capacitor, with associated wire connectors and supply leads attached, to travel 12.7 mm (1/2 inch) in a direction perpendicular to the mounting surface of the terminals.

Exception: The expansion clearance space is not prohibited from being less than 12.7 mm when an investigation determines that the space required for a particular capacitor is provided.

21.11 In addition to the expansion clearance space specified in 21.10, an electrical air spacing between any exposed live part of the capacitor, such as exposed terminals and wire connectors, and any uninsulated live part of opposite polarity or uninsulated, grounded dead-metal parts shall (after expansion) be at least:

a) 1.6 mm (1/16 inch) when the voltage involved does not exceed 300 volts or

b) 3.2 mm (1/8 inch) when the voltage involved exceeds 300 volts.

22 Printed-Wiring Boards

22.1 A printed-wiring board containing circuits involving a risk of fire or electric shock or where separation of the bond between the printed-wiring board foil and the base material results in contact with circuits involving a risk of fire or electric shock, shall comply with the Standard for Printed-Wiring Boards, UL 796.

23 Electrical Spacings

23.1 An electrical spacing shall comply with the requirements specified in this section.

Exception No. 1: A spacing is not required to comply with the requirements in this section within snap switches, lampholders, and similar component devices covered by 2.1.1.

Exception No. 2: A spacing between uninsulated live parts of snap switches, lampholders, and similar component devices and dead metal that is part of the device (including mounting screws, rivets, yoke, clamp, or the like) is not required to comply with the requirements in this section.

Exception No. 3: There are no specifications for spacings in limited-voltage/current circuits or Class 2 circuits. A limited-voltage/current circuit shall comply with Limited-Voltage/Current Circuits, Section 27.

Exception No. 4: Motor drive circuits shall comply with the following spacing requirements in the Standard for Industrial Control Equipment, UL 508:

a) Spacing requirements for constructions in which transient voltages are known and controlled or

b) Alternate spacing requirements under the heading of clearance and creepage distances.

Exception No. 5: For other than providing isolation between different circuits, spacings between traces of different potential on a printed-wiring board are not required to comply with the requirements in this section when:

a) The printed-wiring board has a flammability rating of V-0;

b) The printed-wiring board base material has a minimum Comparative Tracking Index (CTI) of 100 volts; and

c) The circuit complies with the Printed-Wiring Board Abnormal Operation Test, Section 40.

23.2 The electrical spacing through-air and over-surface between lampholder terminals and the metal of a striplight enclosure shall be minimum 12.7 mm (1/2 inch) for voltages up to 600 volts.

23.3 Electrical spacings at field-wiring terminals shall comply with the values specified in Table 23.1.

Table 23.1
Minimum electrical spacings at field-wiring terminals

Potential involved, volts, rms (peak voltages)[a]	Between field-wiring terminals (through-air and over-surface),		Between field-wiring terminals and other uninsulated parts not always of the same polarity,			
	mm	(inch)	mm	(inch)	mm	(inch)
0 – 50 (0 – 71)	3.2	1/8	3.2[b]	1/8[b]	3.2	1/8
51 – 250 (72 – 354)	6.4	1/4	6.4[b]	1/4[b]	6.4	1/4
251 – 600 (355 – 850)	12.7[c]	1/2[c]	12.7[b,c]	1/2[b,c]	9.5	3/8

[a] The values in parentheses are peak voltages. When investigating the voltage of a circuit that produces other than essentially sinusoidal waveform, both rms and peak voltages are considered and the requirement for the larger spacing is to be applied.

[b] These spacings apply to the sum of the spacings involved wherever an isolated dead-metal part is interposed.

[c] A spacing of less than 12.7 mm (1/2 inch) is permitted over-surface or through-air at wiring terminals in a wiring compartment or terminal box that is integral with a motor but shall not be less than 9.5 mm (3/8 inch).

23.4 Except as specified in 23.2, and at other than field-wiring terminals, electrical spacings shall comply with the values specified in Table 23.2 for potentials up to 600 volts rms and 850 volts peak.

Table 23.2
Minimum electrical spacings other than at field-wiring terminals

Potential involved, volts, rms (peak voltages)[a]	Over-surface,		Through-air,	
	mm	(inches)	mm	(inches)
51 – 125 (0 – 177)	1.6[b]	1/16[b]	1.6[b]	1/16[b]
126 – 250 (178 – 354)	2.4[b]	3/32[b]	2.4[b]	3/32[b]
251 – 600 (355 – 850)	12.7[c]	1/2[c]	9.5[c]	3/8[c]

NOTES

1 Film-coated wire is considered an uninsulated live part.

2 On printed-wiring boards, their connectors and board-mounted electrical components wired on the load side of line filters or similar voltage peak reduction networks or components or both, a minimum spacing of 0.58 mm (0.023 inch) plus 0.005 mm (0.0002 inch) per volt peak shall be maintained over-surface and through-air between uninsulated live parts and any other uninsulated conductive part (live or dead) not of the same polarity.

[a] The values in parentheses are peak voltages. When investigating the voltage of a circuit that produces other than essentially sinusoidal waveform, both rms and peak voltages are considered and the requirement for the larger spacing is to be applied.

[b] At closed-in points only, such as a screw and washer construction of an insulated stud mounted in metal, a spacing less than as specified above is permitted but shall not be less than 1.2 mm (3/64 inch).

[c] An over-surface and through-air spacing less than as specified above, between a dead-metal part and film-coated wire that is rigidly supported and held in place on a coil, is permitted but shall not be less than 2.4 mm (3/32 inch).

23.5 Electrical spacings between two circuits involving different voltages, such as between a limited-voltage/current circuit and a line voltage circuit, shall not be less than as required for the higher voltage circuit.

24 Grounding

24.1 All conductive parts of a product not intended to be electrically live that are accessible to persons (including during maintenance and repair), and are capable of inadvertently becoming energized, shall be grounded by being conductively bonded to a common point that incorporates provision for grounding of the luminaire. A product shall be provided with a grounding means to provide connection to the branch-circuit grounding conductor, as specified in 24.2– 24.8.

Exception: A product rated 150 volts DC or less, that is marked as specified in 58.2 to indicate that the product is intended for use only in motion-picture and television studios and similar locations, is not required to comply with the requirements in this section.

24.2 An equipment grounding means shall be:

a) A pigtail lead, pressure terminal connector, or wire-binding screw complying with the requirements of Termination Provisions for Field-Connected Conductors, Section 25, or

b) The grounding pin of an attachment plug or the equivalent.

The equipment grounding means shall be at the same location as the power-supply connection means.

24.3 When insulated, an equipment-grounding conductor, where visible to the installer, shall have a braid of continuous green color with or without a yellow tracer or, when no braid is used, the insulation on the conductor shall be green with or without one or more yellow stripes.

Exception: A conductor having green insulation and a braid of other than green shall be used when the green insulation is readily visible where connections to the branch-circuit supply wires are made.

24.4 An equipment-grounding conductor shall not be terminated on the luminaire by a screw, rivet, or equivalent device that is also used to secure another device or part that is removed during replacement of any electrical device or component.

24.5 The cord of a cord-connected luminaire shall contain an equipment-grounding conductor complying with 24.3 and 24.4.

24.6 A wire-binding screw intended for the field connection of an equipment-grounding conductor shall have a green-colored head that is hexagonal-shaped or slotted, or both.

24.7 A pressure-wire terminal for the connection of an equipment-grounding conductor shall be marked as specified in 57.1.

24.8 All parts required to be grounded shall be conductively connected to the ground termination point such that the resistance between any two points is 0.1 ohm or less as determined in the Grounding Continuity Test, Section 36.

24.9 A bonding wire or jumper connector shall not be terminated by a screw, rivet, or equivalent device that is also used to secure another device, part, or the like, that is removed during replacement of any electrical device or component.

25 Termination Provisions for Field-Connected Conductors

25.1 The termination means provided for field-connected conductors shall consist of a pigtail lead, a pressure terminal connector, a wire-binding screw, or a stud with nut.

25.2 A wire-binding screw or nut shall be 4.2 mm (No. 8) major diameter or larger and shall be provided with a cupped washer to hold the wire under the head of the screw or nut. A sheet metal screw shall not be used.

Exception: A means other than a cupped washer is not prohibited from being used to hold the wire when investigated and determined to be equivalent.

25.3 A wire-binding screw shall not be used to connect a conductor larger than 5.3 mm^2 (10 AWG).

25.4 A terminal plate having a tapped hole for a wire-binding screw shall be of metal not less than 0.76 mm (0.030 inch) thick and shall have not fewer than two full threads in the metal.

Exception: A tapped hole for a screw having a thread pitch of 0.8 mm or less (32 or more threads per inch) is not prohibited from having the metal extruded at the screw hole to provide two full threads.

25.5 The termination provision shall accommodate a conductor sized in accordance with Tables 18.1 and 18.2 for having an ampacity of not less than the current rating of the equipment and:

a) A 60°C (140°F) temperature rating for equipment rated 100 amperes or less or

b) A 75°C (167°F) rating for equipment rated more than 100 amperes.

Exception: The termination provision is not prohibited from accommodating a conductor sized less – or having a temperature rating greater – than as specified in this requirement, when the equipment complies with the temperature test requirements with the different conductor used, and is provided with the marking described in 57.5.

25.6 A pigtail lead shall not be sized less than 4 sizes smaller than the conductor determined in accordance with 25.5 or its exception. For example, a pigtail lead intended for connection with a 3.3 mm^2 (12 AWG) conductor shall not be smaller than 1.3 mm^2 (16 AWG).