3 Hours

2017 NEC Article 517

DISCLAIMER NOTE: This course is APPROVED by the Wisconsin Department of safety and professional services for continuing education to renew your electrical license and is not intended to replace or supersede any state or local adopted codes.
Article 517 is organized into 7 different parts that deal with specific requirements with regards to Health Care Facilities. The specific parts are as follows:

I. General
II. Wiring and Protection
III. Essential Electrical Systems
IV. Inhalation Anesthetizing Locations
V. X-Ray Installations
VI. Communications, Signaling Systems, Data Systems, Fire Alarm Systems, and systems less than 120 volts, Nominal
VII. Isolated Power Systems

Parts I and II are the most general of the article. Part I gives a general scope and the definitions portion of the entire article. Part II is the Wiring and Protection section for all patient care areas of health care facilities. The other five (5) parts are dedicated to specific locations and/or systems throughout Health Care Facilities.

Article 517.1: The provisions of this article shall apply to electrical construction and installation criteria in health care facilities that provide services to humans. The requirements in part II and III not only apply to single function buildings but also intended to be individually used to their respective forms of occupancy with in a multifunction building. (E.g. a doctor’s examining room located within a limited care facility would be required to meet the provisions of 517.10).

Article 517.2 Definitions:

(Revised) Ambulatory Health Care Occupancy. An occupancy used to provide services or treatment simultaneously to four or more patients that provides, on an outpatient basis, one or more of the following:
(1) Treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without assistance of others.
(2) Anesthesia that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others.
(3) Emergency or urgent care for patients who, due to the nature of their injury or illness, are incapable of taking action for self-preservation under emergency conditions without the assistance of others.

Electrical Life-Support Equipment. Electrically powered equipment whose continuous operation is necessary to maintain a patient’s life.

Article 517.2 Definitions:

Equipment Branch. A system of feeders and branch circuits arranged for delayed, automatic, or manual connection to the alternate power source and that serves primarily 3-phase power equipment.

Battery Powered Lighting Units: Individual unit equipment for back up lighting consisting of the following.
1) Rechargeable battery
2) Battery-charging means
3) Provisions for one or more lamps mounted on the equipment, or with terminals for remote lamps or both.
4) Relaying device arranged to energize the lamps automatically upon failure of the power to the unit or equipment.
(NEW) Governing Body. The person or persons who have the overall legal responsibility for the operation of a health care facility.

(Revised) Patient Bed Location: The area of a patients' sleeping bed or the bed or procedure table of a critical care space.

Patient Equipment Grounding Point: A jack or terminal that serves as the collection point for redundant grounding of electrical appliances for patient care vicinity or for grounding other items in order to eliminate electromagnetic interference problems.

Patient Care Vicinity: A space, within a location intended for the examination and treatment of patients, extending 1.8 m (6 ft) beyond the normal location of the patient bed, chair, table, treadmill, or other device that supports the patient during examination and treatment and extending vertically to 2.3 m (7 ft 6 in.) above the floor.

(Revised) Selected Receptacles: A minimum number of receptacles selected by the governing body of a facility as necessary to provide essential patient care and facility services during loss of normal power.

(NEW) Support (Category 4) Space. Space in which failure of equipment or a system is not likely to have a physical impact on patient care.

Task Illumination: provisions for the minimum lighting required to carry out necessary tasks in certain areas, including but not limited to safe access to supplies and equipment, and access to exits.

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**EXAM QUESTIONS**

1. What part of Article 517 would you find the definitions portion?
   A. VII. Isolated Power Systems
   B. II. Wiring and Protection
   C. I. General
   D. V. X-Ray Installations

2. How many parts are there to Article 517?
   A. 7
   B. 5
   C. 9
   D. 8

3. Which part of Article 517 would you find the Wiring and Protection section?
   A. I
   B. VI
   C. VII
   D. II

4. Systems less than 120 volts nominal would be covered in what part of Article 517?
   A. I
   B. VI
   C. VII
   D. II

5. What best defines electrically powered equipment of which continuous operation is necessary to maintain a patient’s life?
   A. Ambulatory Health Care equipment
   B. Electrical Life-Support system
   C. Nursing home equipment
   D. Electrical Life-Support Equipment

6. What best defines a system of circuits and equipment set up for automatic, delayed, or a manual connection to an alternate power source and that serves primarily 3-phase power equipment?
   A. Essential electrical system
   B. Equipment Branch
   C. Isolated power system
   D. Life safety branch
7. Battery powered lighting units are individual equipment for back up illumination consisting of all but one of the following:
   A. Battery charging means
   B. Rechargeable battery
   C. Manual or automatic means of switching
   D. Provisions for one or more lamp to be mounted on the equipment

8. Who has the overall legal responsibility for the operation of a health care facility?
   A. Governing Body
   B. Administrator
   C. Board of directors
   D. Quality of care committee

9. What best defines the space in which the failure of equipment or a system is not likely to have a physical impact on patient care?
   A. Category 4
   B. Category 2
   C. Category 3
   D. Category 1

10. A jack or terminal that serves as the collection point for redundant grounding of electrical appliances for patient care vicinity or for grounding other items in order to eliminate electromagnetic interference problems is known as?
    A. Reference grounding point
    B. Patient equipment grounding point
    C. Selected receptacles
    D. Equipment branch

11. How far does the space within a location intended for the examination and treatment of patients need to extend beyond the normal location of the patient bed to be considered a patient care vicinity?
    A. 6 ft 6 inches
    B. 7 ft 6 inches
    C. 3 ft
    D. 6 ft

12. How high does the vertical space within a location intended for the examination and treatment of patients need to extend to be considered a patient care vicinity?
    A. 6 ft 6 inches
    B. 7 ft 6 inches
    C. 3 ft
    D. 6 ft

13. What best defines the minimum lighting required to carry out necessary tasks in the described areas, including safe access to supplies and equipment, and access to exits with regards to health care facilities?
    A. Task Illumination
    B. Critical Branch
    C. Emergency Lighting
    D. Support lighting

517.10 (A) Applicability. Part II shall apply to patient care space of all health care facilities.

517.10 (B) Not Covered. Part II shall not apply to the following:
   (1) Business offices, corridors, waiting rooms, and the like in clinics, medical and dental offices, and outpatient facilities
   (2) Areas of nursing homes and limited care facilities wired in accordance with Chapters 1 through 4 of this Code where these areas are used exclusively as patient sleeping rooms.

517.13 Grounding of Receptacles and Fixed Electrical Equipment in Patient Care Spaces. Wiring in patient care areas shall comply with 517.13(A) and (B).
(A) Wiring Methods. All branch circuits serving patient care spaces shall be provided with an effective ground-fault current path by installation in a metal raceway system, or a cable having a metallic armor or sheath assembly. The metal raceway system, or metallic cable armor, or sheath assembly shall itself qualify as an equipment grounding conductor in accordance with 250.118.

517.14 Panel Board Bonding. The equipment grounding terminal buses of the normal and essential branch-circuit panel boards serving the same individual patient care vicinity shall be connected together with an insulated continuous copper conductor not smaller than 10 AWG. Where two or more panel boards serving the same individual patient care vicinity are served from separate transfer switches on the essential electrical system, the equipment grounding bus of those panels shall be connected together with an insulated continuous copper conductor no smaller than a 10 AWG. This conductor shall be permitted to be broken in order to terminate on the equipment grounding terminal bus in each panel board.

(Revised) 517.16 (A) Inside of a Patient Care Vicinity. An isolated grounding receptacle shall not be installed within a patient care vicinity.

517.18 General Care (Category 2) Spaces. (A) Patient Bed Location. Each patient bed location shall be supplied by at least two branch circuits, one from the critical branch and one from the normal system. All branch circuits from the normal system shall originate in the same panelboard. The electrical receptacles or the cover plate for the electrical receptacles supplied from the critical branch shall have a distinctive color or marking so as to be readily identifiable and shall also indicate the panelboard and branch-circuit number supplying them. Branch circuits serving patient bed locations shall not be part of a multiwire branch circuit.

Exception NO 1: Branch circuits serving only special purpose outlets or receptacles, such as portable X-ray outlets, shall not be required to be served from the same panel board or distribution panel.

Exception NO 2: Requirements of 517.18(A) shall not apply to patient bed locations in clinics, medical and dental offices, and outpatient facilities; psychiatric, substance abuse, and rehabilitation hospitals; sleeping rooms of nursing homes and limited care facilities meeting the requirements of 517.10(B)(2)

Exception NO 3: A general care (Category 2) patient bed location served from two separate transfer switches on the emergency system shall not be required to have circuits from the normal system.

517.19 Critical Care (Category 1) Spaces. (A) Patient Bed Location Branch Circuits. Each patient bed location shall be supplied by at least two branch circuits, one or more from the critical branch and one or more circuits from the normal system. At least one branch circuit from the critical branch shall supply an outlet(s) only at that bed location.

517.19 Critical Care (Category 1) Spaces (B) Patient bed location receptacles. (1) Minimum Number and Supply. Each patient bed location shall be provided with a minimum of 14 receptacles, at least one of which shall be connected to either of the following:

(1) The normal system branch circuit required in 517.19(A)

(2) A critical branch circuit supplied by a different transfer switch than the other receptacles at the same patient bed location

(Revised) 517.19 Critical Care (Category 1) Spaces (C) Operating Room Receptacles. (1) Minimum Number and Supply. Each operating room shall be provided with a minimum of 36 receptacles divided between at least two branch circuits. At least 12 receptacles, but no more than 24, shall be connected to either of the following:

(1) The normal system branch circuit required in 517.19(A)

(2) A critical branch circuit supplied by a different transfer switch than the other receptacles at the same location.
14. What part of Article 517 would NOT apply directly to a dental office installation?
   A. III
   B. II
   C. IV
   D. VI

15. What is the minimum size equipment grounding conductor that can be used to tie together the terminal buses of the normal and essential branch-circuit panel boards that serve the same individual patient care vicinity?
   A. 8 AWG
   B. 6 AWG
   C. 4 AWG
   D. 10 AWG

16. What are all branch circuits serving patient care areas required to be provided with?
   A. Labels
   B. Effective ground-fault current path
   C. Identified terminals
   D. All listed answers

17. What type of receptacles are NOT permitted within a patient care vicinity?
   A. Any receptacle Orange in color
   B. 15 amp
   C. Commercial grade
   D. Isolated ground receptacles

18. How are electrical receptacles or cover plates supplied from the critical branch required to be identified?
   A. Markings
   B. A distinctive color
   C. Labels
   D. All listed answers

19. A general care patient bed location served from two separate transfer switches on the critical branch is not required to have an additional circuit from what listed system?
   A. Normal system
   B. Critical system
   C. Standby system
   D. General care patient bed locations cannot be served by a transfer switch

20. How many circuits are required at each patient bed location?
   A. One
   B. Two
   C. Six
   D. Three

21. How many receptacles are required at each patient bed location?
   A. Twelve
   B. Ten
   C. Eight
   D. Fourteen

22. How many receptacles are required in an operating room?
   A. 12
   B. 36
   C. 24
   D. 18

23. What is the minimum number of receptacles that are required to be connected to the normal or critical branch in an operating room?
   A. 12
   B. 36
   C. 24
   D. 18
517.19 Critical Care (Category 1) Spaces (G) Isolated power system equipment grounding. Where an isolated ungrounded power source is used and limits the first fault current to a low magnitude, the equipment grounding conductor associated with the secondary circuit shall be permitted to run outside of the enclosure of the power conductors in the same circuit.

517.19 Critical Care (Category 1) Spaces (H) Special Purpose Receptacle Grounding. The equipment grounding conductor for special purpose outlets, such as operation of mobile x-ray equipment, shall be extended to the reference grounding points of branch circuits for all locations likely to be served from each outlet. Where such a circuit is served from an isolated ungrounded system, the grounding conductor shall not be required to be run with the power conductors; however the equipment grounding terminal of the special purpose outlet shall be connected to the reference grounding point.

517.20 Wet Procedure Locations (A) Receptacles and fixed equipment. Wet procedure locations shall be provided with special protection against electric shock by one of the following:

(1) Power distribution system that inherently limits the possible ground fault current due to the first fault to a low value, without interrupting the power supply.

(2) Power distribution system in which the power supply is interrupted if the ground fault current does, in fact, exceed a value of 6 mA.

517.20 Wet Procedure Locations (B) Isolated Power Systems. Where an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment, and the isolated power system shall be designed and installed according to 517.160.

517.21 Ground Fault Circuit Interrupter Protection for Personnel. Ground fault circuit interrupter for protection of personnel shall not be required for receptacles installed in those critical care (Category 1) spaces where the toilet and basin are installed within the patient room.

517.25 Essential Electrical System Scope. The essential electrical system for these facilities shall comprise a system capable of supplying a limited amount of lighting and power service, which is considered essential for life safety and orderly cessation of procedures during the time normal electrical service, is interrupted for any reason. This includes clinics, medical and dental offices, outpatient facilities, nursing homes, limited care facilities, hospitals and other health care facilities serving patients.

517.31 Requirements for the Essential Electrical System. (A) Separate Branches. Essential electrical systems for hospitals shall be comprised of three separate branches capable of supplying a limited amount of lighting and power service that is considered essential for life safety and effective hospital operation during the time the normal electrical service is interrupted for any reason. The three branches are life safety, critical, and equipment.

The division between the branches shall occur at transfer switches where more than one transfer switch is required.

24. What are operating room nonlocking-type receptacles required to be listed as?
A. 20 amp
B. Hospital Grade
C. Continuous duty
D. All listed answers
517.31 Requirements for the Essential Electrical System. (B) Transfer Switches. The number of transfer switches to be used shall be based on reliability and design. Each branch of the essential electrical system shall have one or more transfer switches. One transfer switch and downstream distribution system shall be permitted to serve one or more branches in a facility with a maximum demand on the essential electrical system of 150 kVA.

517.31 Requirements for the Essential Electrical System. (B)(1) Optional Loads. Loads served by the generating equipment not specifically named in Article 517 shall be served by their own transfer switches such that the following conditions apply:

1. These loads shall not be transferred if the transfer will overload the generating equipment.
2. These loads shall be automatically shed upon generating equipment overloading.

517.31 Requirements for the Essential Electrical System. (C) Wiring Requirements. (1) Separation from Other Circuits. The life safety branch and critical branch of the essential electrical system shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceways, boxes, or cabinets with each other or other wiring.

Where general care locations are served from two separate transfer switches on the essential electrical system in accordance with 517.18(A), Exception No. 3, the general care circuits from the two separate systems shall be kept independent of each other.

Where critical care locations are served from two separate transfer switches on the essential electrical system in accordance with 517.19(A), Exception No. 2, the critical care circuits from the two separate systems shall be kept independent of each other.

### EXAM QUESTIONS

25. If an isolated ungrounded power source is used to limit the first fault current to a low magnitude, what secondary conductor is allowed to be run outside of the enclosure?
   A. Grounded conductor
   B. Equipment grounding conductor
   C. Phase line side conductor
   D. Primary load side conductor

26. Where is the equipment grounding conductor for mobile x-ray equipment required to be extended?
   A. The line side conductors used for the outlet
   B. The grounded conductor points of branch circuits for all locations
   C. The Service
   D. The grounding points of branch circuits for all locations likely to be served

27. Wet procedure location patient care areas are required to be provided with special protection against what?
   A. Harmonics
   B. Electric shock
   C. Eddy currents
   D. All listed answers

28. What is isolated power equipment required to be listed as?
   A. Hospital Grade
   B. Commercial Grade
   C. Isolated power equipment
   D. Nema 3R

29. Ground fault circuit interrupter for protection of personnel where the toilet and basin are installed within the patient room is not required in what area?
   A. Critical care areas
   B. Out Patient areas
   C. Waiting room areas
   D. Nursing stations
30. The Essential Electrical Systems are required to do what in all health care facilities?
   A. Supply a limited amount of lighting and power service
   B. Supply only equipment power
   C. Supply emergency power to only hospitals
   D. Supply emergency lighting to dental offices

31. How many separate branches make up the Essential Electrical System?
   A. 4
   B. 1
   C. 2
   D. 3

32. What are the names of the branches that make up the Essential Electrical System?
   A. Life safety
   B. Critical
   C. Equipment
   D. All listed answers

33. What determines the number of transfer switches required for the Essential Electrical System?
   A. Load considerations
   B. Design and Reliability
   C. Output rating
   D. All listed answers

34. What branches of the essential electrical system are required to be installed independent of all other wiring and equipment?
   A. Equipment branch and critical branch
   B. Life safety branch and emergency branch
   C. Transfer switch and emergency branch
   D. Life safety branch and the critical branch

517.31 Wiring Requirements (C)(1) Separation from Other Circuits.
Wiring of the life safety branch and the critical branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits not part of the branch where such wiring complies with one of the following:
(1) Is in transfer equipment enclosures
(2) Is in exit or emergency luminaires supplied from two sources
(3) Is in a common junction box attached to exit or emergency luminaires supplied from two sources
(4) Is for two or more circuits supplied from the same branch and same transfer switch

The wiring of the equipment branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits that are not part of the essential electrical system.

517.31 Wiring Requirements (C)(2) Isolated Power Systems.
Where isolated power systems are installed in any of the areas in 517.34(A)(1) and (A)(2), each system shall be supplied by an individual circuit serving no other load.

(Revised) 517.31 Wiring Requirements (C)(3) Mechanical Protection of the Essential Electrical System.
The wiring of the life safety and critical branches shall be mechanically protected. Where installed as branch circuits in patient care spaces, the installation shall comply with the requirements of 517.13(A) and (B). Only the following wiring methods shall be permitted:
(1) Nonflexible metal raceways, Type MI cable, Type RTRC marked with the suffix –XW, or Schedule 80 PVC conduit. Nonmetallic raceways shall not be used for branch circuits that supply patient care areas.
(2) Where encased in not less than 50mm (2in) of concrete, Schedule 40 PVC conduit, flexible nonmetallic or
jacketed metallic raceways, or jacketed metallic cable assemblies listed for installation in concrete. Nonmetallic raceways shall not be used for branch circuits that supply patient care areas.

(3) Listed flexible metal raceways and listed metal sheathed cable assemblies in any of the following:
   a. Where used in listed prefabricated medical head walls.
   b. In listed office furnishings.
   c. Where fished into existing walls or ceilings, not otherwise accessible and not subject to physical damage.
   d. Where necessary for flexible connection to equipment.
   e. For equipment that requires a flexible connection due to movement, vibration, or operation
   f. Luminaires installed in rigid ceiling structures where there is no access above the ceiling space after the luminaire is installed

(4) Flexible power cords of appliances or other utilization equipment connected to the emergency system.

(5) Cables for class 2 or class 3 systems permitted by Part VI of this article, with or without raceways.

**EXAM QUESTIONS**

35. According to Article 517, when would it be permissible for the life safety branch and the critical branch of the essential electrical system to share a common J-box with conductors of different systems?
   A. If only one circuit is in the box and is dedicated to the common panel
   B. If no other enclosure penetrates the electrical panel
   C. If two or more circuits supplied from the same branch and same transfer switch
   D. There are no exceptions to this rule

36. What type of circuit is required to comply 517.34(A)(1) and (A)(2)?
   A. Dedicated
   B. Variable voltage
   C. Frequency driven
   D. One that is identified with distinctive marking(s)

37. How is the wiring of the life safety and critical branches required to be protected?
   A. Isolation switching
   B. Mechanically
   C. Through interlocking means
   D. With Edison fuses

38. What is the minimum amount of concrete required to cover schedule 40 PVC so it can be used in a patient care area?
   A. 3 inches
   B. 2 inches
   C. 4 inches
   D. 1 inches

39. Flexible metal raceways and listed metal sheathed cable assemblies for a patient care area are allowed only in which of the following?
   A. Where fished into existing walls or ceilings, not otherwise accessible and not subject to physical damage.
   B. Mechanical rooms
   C. Between the emergency and normal power systems
   D. Coming out of concrete

40. What class of Cables for systems permitted by Part VI of Article 517 can be installed with or without raceways?
   A. Class 3 or class 4
   B. Class 1 or class 3
   C. Class 2 or class 4
   D. Class 2 or class 3
517.31 Hospitals (D) Capacity of Systems. The essential electrical system shall have the capacity and rating to meet the maximum actual demand likely to be produced by the connected load. Feeders shall be sized in accordance with 215.2 and Part III of Article 220. The generator set(s) shall have the capacity and rating to meet the demand produced by the load at any given time. Demand calculations for sizing of the generator set(s) shall be based on any of the following:

(1) Prudent demand factors and historical data
(2) Connected load
(3) Feeder calculations based on Article 220
(4) Any combination of above.

The sizing requirements in 700.4 and 701.4 shall not apply to hospital generator sets.

517.31 (E) Receptacle Identification. The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the essential electrical system shall have a distinctive color or marking so as to be readily identifiable.

(Revised) 517.33 Life Safety Branch. No function other than those listed in 517.33 (A) through (H) shall be connected to the life safety branch. The life safety branch of the essential electrical system shall supply power for the following lighting, receptacles, and equipment:

517.33 (A) Illumination of Means of Egress. Illumination of means of egress, such as lighting required for corridors, passageways, stairways, and landings at exit doors, and all necessary ways of approach to exits. Switching arrangements to transfer patient corridor lighting in hospitals from general illumination circuits to night illumination circuits shall be permitted, provided only one of the two circuits can be selected and both circuits cannot be extinguished at the same time.

517.33 (B) Exit Signs. Exit signs and directional signs will be connected to the life safety branch of the emergency system.

(Revised) 517.33 (C) Alarm and Alerting Systems. Alarm and alerting systems including all of the following:

(1) Fire alarms
(2) Alarms required for systems used for the piping of nonflammable medical gases.
(3) Mechanical, control, and other accessories required for effective life safety systems operation shall be permitted to be connected to the life safety branch.

517.33 Life Safety Branch (D) Communication Systems. Hospital communications systems, where used for issuing instructions during emergency conditions can be connected to the life safety branch.

(Revised) 517.33 Critical Branch (A) Task Illumination and Selected Receptacles. The critical branch of the essential electrical system shall supply power for task illumination, fixed equipment, selected receptacles, and special power circuits serving the following areas and functions related to patient care:
(1) Critical care (Category 1) spaces that utilize anesthetizing gases – task illumination, selected receptacles, and fixed equipment.

(2) The isolated power system in special environments.

(3) Patient care Spaces – task illumination and selected receptacles in the following areas:
   (a) Infant nurseries
   (b) Medication preparation areas
   (c) Pharmacy dispensing areas
   (d) Selected acute nursing areas
   (e) Psychiatric bed areas (omit receptacles)
   (f) Ward treatment rooms
   (g) Nurses’ stations (unless adequately lighted by corridor luminaries)

(4) Additional specialized patient care task illumination and receptacles, where needed.

(5) Nurse call system

(6) Blood, bone, and tissue banks

(7) Telephone and data equipment rooms and closets

(8) Task illumination, selected receptacles, and selected power circuits for the following:
   (a) General care beds (at least one duplex receptacle in each patient bedroom)
   (b) Angiographic labs
   (c) Cardiac catheterization labs
   (d) Coronary care units
   (e) Hemodialysis rooms or areas
   (f) Emergency room treatment areas (selected)
   (g) Human physiology labs
   (h) Intensive care units
   (i) Postoperative recovery rooms (selected)

(9) Additional task illumination, receptacles, and selected power circuits needed for effective facility operation, including single-phase fractional horsepower motors, shall be permitted to be connected to the critical branch.

EXAM QUESTIONS

41. The essential electrical system is required to have adequate capacity to meet what for its connected loads?
   A. The capacity for all battery backed up loads
   B. Minimum for life safety branches
   C. Maximum actual demand
   D. Emergency and all its normal operating systems

42. The demand calculations in Article 517 for the sizing of generator conductor set(s) is required to be based on which of the following?
   A. Connected load
   B. Feeder calculations based on Article 220
   C. Prudent demand factors and historical data
   D. All listed answers

43. How are the cover plates for the essential electrical system required to be identified?
   A. Red
   B. Marked with a label as “EES”
   C. Just be different from the rest in some way
   D. Any listed answer

44. What branch of the essential electrical system is required for all necessary ways of approach to exits?
   A. Critical
   B. Life Safety
   C. Equipment
   D. Any listed answer
15

517.34 Critical Branch (C) Subdivision of the Critical Branch. It shall be permitted to subdivide the critical branch into two or more branches.

Informational Note: It is important to analyze the consequences of supplying an area with only critical care branch power when failure occurs between the area and the transfer switch. Some proportion of normal and critical power or critical power from separate transfer switches may be appropriate.

(Revised) 517.35 Equipment Branch Connection to Alternate Power Source. The equipment system shall be installed and connected to the alternate power source such that the equipment described in 517.35(A) is automatically restored to operation at appropriate time-lag intervals following the energizing of the emergency system. Its arrangement shall also provide for the subsequent connection of equipment described in 517.35(B).

Exception: For essential electrical systems less than 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment system shall be permitted.

517.35 (A) Equipment for Delayed Automatic Connection. The following equipment shall be permitted to be arranged for delayed automatic connection to the alternate power source:

1. Central suction systems serving medical and surgical functions, including controls. Such suction systems shall be permitted on the critical branch.

2. Sump pumps and other equipment required to operate for the safety of major apparatus, including associated control systems and alarms.
Compressed air systems serving medical and surgical functions, including controls. Such air systems shall be permitted on the critical branch.

Smoke control and stair pressurization systems, or both.

Kitchen hood supply or exhaust systems, or both, if required to operate during a fire in or under the hood.

Supply, return, and exhaust ventilating systems for airborne infectious/isolation rooms, protective environment rooms, exhaust fans for laboratory fume hoods, nuclear medicine areas where radioactive material is used, ethylene oxide evacuation, and anesthesia evacuation. Where delayed automatic connection is not appropriate; such ventilation systems shall be permitted to be placed on the critical branch.

Supply, return, and exhaust ventilating systems for operating and delivery rooms.

Supply, return, exhaust ventilating systems and/or air-conditioning systems serving telephone equipment rooms and closets and data equipment rooms and closets.

**Exception:** Sequential delayed automatic connection to the alternate power source to prevent overloading the generator shall be permitted where engineering studies indicate it is necessary.

### 517.35 (B) Equipment for Delayed Automatic or Manual Connection.

The following equipment shall be permitted to be arranged for either delayed automatic or manual connection to the alternate power source:

1. Heating equipment to provide heating for operating, delivery, labor, recovery, intensive care, coronary care, nurseries, infection/isolation rooms, emergency treatment spaces, and general patient rooms and pressure maintenance (jockey or make-up) pump(s) for water based fire protection systems.

**Exception:** Heating of general patient rooms and infection/isolation rooms during disruption of the normal source shall not be required under any of the following conditions:

   a. The outside design temperature is higher than −6.7°C (20°F).

   b. The outside design temperature is lower than −6.7°C (20°F), and where a selected room(s) is provided for the needs of all confined patients, only such room(s) need be heated.

   c. The facility is served by a dual source of normal power.

**Informational Note No. 1:** The design temperature is based on the 97.5 percent design value as shown in Chapter 24 of the ASHRAE Handbook of Fundamentals (2013).

**Informational Note No. 2:** For a description of a dual source of normal power, see 517.30(C).

2. An elevator(s) selected to provide service to patient, surgical, obstetrical, and ground floors during interruption of normal power. In instances where interruption of normal power would result in other elevators stopping between floors, throw-over facilities shall be provided to allow the temporary operation of any elevator for the release of patients or other persons who may be confined between floors.

3. Hyperbaric facilities.

4. Hypobaric facilities.

5. Automatically operated doors

6. Minimal electrically heated autoclaving equipment shall be permitted to be arranged for either automatic or manual connection to the alternate source.

7. Controls for equipment listed in 517.35.

8. Other selected equipment shall be permitted to be served by the equipment system.
EXAM QUESTIONS

51. **What is permissible for the critical branch of the essential electrical system to be subdivided into?**
   A. Two or more branches
   B. A Supplemental circuit
   C. Exit sign circuit
   D. Stairwell emergency lighting

52. **Where is the equipment branch required to be connected?**
   A. UPS System
   B. Critical Branch
   C. Alternate power source
   D. General waiting rooms and corridors

53. **Which of the following equipment is not permitted to be arranged for delayed automatic connection to the alternate power source with regards to health care facilities?**
   A. Lighting control panels in critical care areas
   B. Sump pumps and other equipment required to operate for the safety of major apparatus
   C. Smoke control and stair pressurization systems, or both
   D. Central suction systems serving medical and surgical functions, including controls

54. **What type of sequential automatic connection to the alternate power source to prevent overloading the generator in a health care facility is permitted where engineering studies indicate it is necessary?**
   A. Relayed
   B. Delayed
   C. Bypassed
   D. Ramp-up

55. **Article 517 does not allow what listed equipment to be arranged for either delayed automatic or manual connection to the alternate power source.**
   A. Neonatal infant care unit machines
   B. Automatically operated doors
   C. Hypobaric facilities
   D. Hyperbaric facilities

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**517.35 (C) AC Equipment for No Delayed Automatic Connection.** Generator accessories, including but not limited to, the transfer fuel pump, electrically operated louvers, and other generator accessories essential for generator operation, shall be arranged for automatic connection to the alternate power source.

**(Revised) 517.41 (A) Two Independent Power Sources.** Essential electrical systems shall have a minimum of the following two independent sources of power: a normal source generally supplying the entire electrical system and one or more alternate sources for use when the normal source is interrupted.

**(Revised) 517.41 (B) Types of Power Sources.** Where the normal source consists of generating units on the premises, the alternate source shall be either another generating set or an external utility service.

**(Revised) 517.41 (C) Location of Essential Electrical System Components.** Essential electrical systems shall be located to minimize interruptions caused by natural forces common to the area (e.g., storms, floods, earthquakes, or hazards created by adjoining structures or activities). Installations of electrical services shall be located to reduce possible interruption of normal electrical services resulting from similar causes as well as possible disruption of normal electrical service due to internal wiring and equipment failures. Feeders shall be located to give physical separation of the feeders of the alternate source and from the feeders of the normal electrical source to prevent possible simultaneous interruption.

**(Revised) 517.42 Essential Electrical Systems (A) General.** Essential electrical systems for nursing homes and limited care facilities shall be divided into the following two branches, the life safety branch and the equipment branch. The division between the branches shall occur at transfer switches where more than one transfer switch is required.
517.42 Essential Electrical Systems (B) Transfer Switches. Transfer Switches. The number of transfer switches to be used shall be based on reliability, design, and load considerations.

(1) Each branch of the essential electrical system shall have one or more transfer switches.

(2) One transfer switch shall be permitted to serve one or more branches or systems in a facility with a continuous load on the switch of 150 kVA (120 kW) or less.

517.42 Essential Electrical Systems (C) Capacity of System. The essential electrical system shall have adequate capacity to meet the demand for the operation of all functions and equipment to be served by each branch at one time.

(Revised) 517.42 Essential Electrical Systems (D) Separation from Other Circuits. The life safety branch and equipment branch shall be kept entirely independent of all other wiring and equipment. These circuits shall not enter the same raceways, boxes, or cabinets with other wiring except as follows:

(1) In transfer switches

(2) In exit or emergency luminaries supplied from two sources

(3) In a common junction box attached to exit or emergency luminaries supplied from two sources

The wiring of the critical branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits that are not part of the life safety branch.

517.42 Essential Electrical Systems (E) Receptacle Identification. The electrical receptacles or the cover plates for the electrical receptacles supplied from the life safety or equipment branches shall have a distinctive color or marking to be readily identifiable.

517.43 Automatic Connection to Life Safety Branch. The life safety branch shall be installed and connected to the alternate source of power so that all functions specified herein shall be automatically restored to operation within 10 seconds after the interruption of the normal source. No functions other than those listed in 517.43(A) through (G) shall be connected to the life safety branch. The life safety branch shall supply power for the following lighting, receptacles, and equipment.

517.43 Automatic Connection to Life Safety Branch (A) Illumination of Means of Egress. The illumination of means of egress as is necessary for corridors, passageways, stairways, landings, and exit doors and all ways of approach to exits. Switching arrangement to transfer patient corridor lighting from general illumination circuits shall be permitted, providing only one of two circuits can be selected and both circuits cannot be extinguished at the same time.

517.43 Automatic Connection to Life Safety Branch (B) Exit Signs. Exit signs and exit directional signs.

517.43 Automatic Connection to Life Safety Branch (C) Alarm and Alerting Systems. The alarm and alerting systems connected to the life safety branch circuit including the following:

(1) Fire alarms

(2) Alarms required for systems used for the piping of nonflammable medical gases

517.43 Automatic Connection to Life Safety Branch (D) Communications Systems. The communications systems, where used for issuing instructions during emergency conditions.

517.43 Automatic Connection to Life Safety Branch (E) Dining and Recreation Areas. Sufficient lighting in dining and recreation areas to provide illumination to exit ways at a minimum of 5ft-candels.

517.43 Automatic Connection to Life Safety Branch (F) Generator Set Location. Task illumination and selected receptacles in the generator set location.
517.43 Automatic Connection to Life Safety Branch (G) Elevators. Elevator cab lighting, control, communications, and signal systems.

(Revised) 517.44 Connection to Equipment Branch. The equipment branch shall be installed and connected to the alternate power source so that the equipment listed in 517.44(A) shall be automatically restored to operation at appropriate time-lag intervals following the restoration of the life safety branch to operation.

The equipment branch arrangement shall also provide for the additional connection of equipment listed in 517.44(B).

Exception: For essential electrical systems under 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment system shall be permitted.

## Exam Questions

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<th>Question</th>
<th>Options</th>
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| 56. What type of connection is required to be made to the alternate power source for generator accessories essential for generator operation? | A. Solidly grounded  
B. Manual  
C. Automatic  
D. Remote                                                                 |
| 57. What is the minimum amount of independent power sources required to make up the essential electrical system? | A. Three  
B. One  
C. Five  
D. Two                                                                 |
| 58. Careful consideration must be given to the location of the essential electrical system components to minimize interruptions due to what? | A. Regular scheduled maintenance  
B. Natural forces  
C. Load demands  
D. Life safety circuits                                                                 |
| 59. A limited care facility's essential electrical system is required to be comprised of how many separate branches? | A. 1  
B. 4  
C. 3  
D. 2                                                                 |
| 60. What determines the number of transfer switches to be used for a limited care facility's Essential Electrical System? | A. Load considerations  
B. Design  
C. Reliability  
D. All listed answers                                                                 |
| 61. The essential electrical system in a nursing home is required to have adequate capacity for what listed option? | A. Have interlocking disconnects  
B. Power all branches simultaneously  
C. Meet the demand for the operation of all functions and equipment to be served by each branch at one time  
D. All listed answers                                                                 |
| 62. How is the life safety branch of the essential electrical system in a nursing home is required to be installed? | A. Separated from all other wiring and equipment  
B. Combined and identified from all other wiring and equipment  
C. Combined with the equipment branch raceway  
D. No Special requirements                                                                 |
| 63. What branch is permitted to occupy the same raceways, boxes, or cabinets of other circuits that are not part of the life safety branch? | A. Life support  
B. Emergency  
C. Critical  
D. Life safety                                                                 |
(Revised) 517.44 Connection to Equipment Branch (A) Delayed Automatic Connections to Equipment Branch. The following equipment shall be permitted to be connected to the equipment branch and shall be arranged for delayed automatic connection to the alternate power source:

(1) Task illumination and selected receptacles in the following:
   a. Patient care spaces
   b. Medication preparation spaces
   c. Pharmacy dispensing areas
   d. Nurses’ stations (unless adequately lighted by corridor luminaries)

(2) Supply, return, and exhaust ventilating systems for airborne infectious isolation rooms

(3) Sump pumps and other equipment required to operate for the safety of major apparatus and associated control systems and alarms

(4) Smoke control and stair pressurization systems

(5) Kitchen hood supply or exhaust systems, or both, if required to operate during a fire in or under the hood

(6) Nurse call systems

(Revised) 517.44 Connection to Critical Branch (B) Delayed Automatic or Manual Connection to the Equipment Branch. The following equipment shall be permitted to be connected to the critical equipment branch circuit and shall be arranged for either delayed automatic or manual connection to the alternate power source:

(1) Heating equipment to provide heating for patient rooms.

Exception: Heating of general patient rooms during disruption of the normal source shall not be required under any of the following conditions:

64. What is the maximum time the life safety branch circuit has to automatically restore power after the interruption of the normal source occurs?
   A. 20 seconds
   B. 10 seconds
   C. 30 seconds
   D. 15 seconds

65. What branch of the essential electrical system is required for all necessary ways of approach to exits in nursing homes?
   A. Critical
   B. Life Safety
   C. Equipment
   D. Any listed answer

66. Switching from day illumination to night illumination circuits for nursing home corridor lighting is acceptable if what happens?
   A. Both are on
   B. Both are off
   C. Only one of the two circuits can be selected
   D. Both circuits can be switched simultaneously

67. What branch of the essential electrical system is required to be used for all exit and directional signs used in limited care facilities?
   A. Critical branch
   B. Life safety branch
   C. Equipment branch
   D. Emergency branch

68. Which of the following is NOT required to be connected to the life safety branch in a limited care facility?
   A. Generator set
   B. Elevators
   C. Parking lot lights
   D. Dining and recreation

69. What is the maximum KVA that deletion of the time-lag intervals feature for delayed automatic connection to the equipment branch is permitted?
   A. 150 kVA
   B. 200 kVA
   C. 100 kVA
   D. 500 kVA
The outside design temperature is higher than $-6.7°C$ (20°F).

The outside design temperature is lower than $-6.7°C$ (20°F) and where a selected room(s) is provided for the needs of all confined patients, only such room(s) need be heated.

The facility is served by a dual source of normal power as described in 517.41(C), Informational Note.

Informational Note: The outside design temperature is based on the 97.5 percent design values as shown in Chapter 24 of the ASHRAE Handbook of Fundamentals (2013).

Elevator service — in instances where disruption of power would result in elevators stopping between floors, throw-over facilities shall be provided to allow the temporary operation of any elevator for the release of passengers. For elevator cab lighting, control, and signal system requirements, see 517.43(G).

Additional illumination, receptacles, and equipment shall be permitted to be connected only to the critical branch.

517.60 Anesthetizing Location Classification (A) Hazardous (Classified) Location. (1) Use Location. In a location where flammable anesthetics are employed, the entire area shall be considered to be a Class I, Division 1 location that extends upward to a level 1.52 m (5 ft) above the floor. The remaining volume up to the structural ceiling is considered to be above a hazardous (classified) location.

517.60 Essential Electrical Systems for Other Health Care Facilities. (2) Storage Location. Any room or location in which flammable anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location from floor to ceiling.

**Exam Questions**

70. Which of the following does NOT have to be connected to the delayed automatic connection of the critical branch circuit?
   A. Waiting rooms
   B. Pharmacy dispensing areas
   C. Medication preparation areas
   D. Nurses’ stations (unless adequately lighted by corridor luminaries)

71. Sump pumps are some of the equipment permitted to be connected to the ________ and arranged for auto delay.
   A. Life safety
   B. Critical equipment branch
   C. Emergency power
   D. Equipment Branch

72. What do throw-over facilities allow?
   A. Equipment operation for medical gas equipment
   B. The temporary operation of any elevator for the release of passengers
   C. Escalator power and function during a power loss situation
   D. Annunciator panels for nursing stations

73. How high does the classification area extend vertically above flammable anesthetics use locations?
   A. To the ceiling
   B. 7 feet
   C. 5 feet
   D. 10 feet

74. How high does the classification area extend vertically above flammable anesthetics storage locations?
   A. To the ceiling
   B. 7 feet
   C. 5 feet
   D. 10 feet
517.60 Anesthetizing Location Classification (B) Other-Than-Hazardous (Classified) Location. Any inhalation anesthetizing location designated for the exclusive use of nonflammable anesthetizing agents shall be considered to be an other-than-hazardous (classified) location.

517.61 Wiring and Equipment (A) Within Hazardous (Classified) Anesthetizing Locations.

(1) Isolation. Except as permitted in 517.160, each power circuit within, or partially within, a flammable anesthetizing location as referred to in 517.60 shall be isolated from any distribution system by the use of an isolated power system.

(2) Design and Installation. Where an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment and the isolated power system shall be designed and installed in accordance with 517.160.

(3) Equipment Operating at More Than 10 Volts. In hazardous (classified) locations referred to in 517.60, all fixed wiring and equipment and all portable equipment, including lamps and other utilization equipment, operating at more than 10 volts between conductors shall comply with the requirements of 501.1 through 501.25, and 501.100 through 501.150, and 501.30(A) and 501.30(B) for Class I, Division 1 locations. All such equipment shall be specifically approved for the hazardous atmospheres involved.

(4) Extent of Location. Where a box, fitting, or enclosure is partially, but not entirely, within a hazardous (classified) location(s), the hazardous (classified) location(s) shall be considered to be extended to include the entire box, fitting, or enclosure.

(5) Receptacles and Attachment Plugs. Receptacles and attachment plugs in a hazardous (classified) location(s) shall be listed for use in Class I, Group C hazardous (classified) locations and shall have provision for the connection of a grounding conductor.

(6) Flexible Cord Type. Flexible cords used in hazardous (classified) locations for connection to portable utilization equipment, including lamps operating at more than 8 volts between conductors, shall be of a type approved for extra hard usage in accordance with Table 400.4 and shall include an additional conductor for grounding.

(7) Flexible Cord Storage. A storage device for the flexible cord shall be provided and shall not subject the cord to bending at a radius of less than 75 mm (3 in.).

517.61 Wiring and Equipment (B)(6) Above Hazardous (Classified) Anesthetizing Locations. Receptacles and attachment plugs rated 250 volts, for connection of 50-ampere and 60-ampere ac medical equipment for use above hazardous (classified) locations, to be arranged so that the 60-ampere receptacle will accept either the 50-ampere or the 60-ampere plug. Fifty ampere receptacles shall be designed so as not to accept the 60-ampere attachment plug. The attachment plugs shall be of the 2-pole, 3-wire design with a third contact connecting to the insulated (green or green with yellow stripe) equipment grounding conductor of the electrical system.
EXAM QUESTIONS

75. What type of location is an inhalation anesthetizing location designated for the exclusive use of nonflammable anesthetizing agents know as?
   A. Patient examination location
   B. Class 1 Division 1
   C. Nonflammable classified area
   D. Other-than-hazardous (classified) location

76. What type of power supply are power circuits in or partially in a flammable anesthetizing location required to have?
   A. Variable current
   B. Direct Current
   C. Single phase
   D. Isolated

77. What section requires a flammable anesthetizing location to be isolated from any other distribution systems?
   A. 517.61
   B. 517.60
   C. 517.32
   D. 517.61(A)(7)

78. What is the maximum voltage between conductors that portable hospital equipment used in a hazardous location can be operated without having to meet the requirements of Article 501.30(A)?
   A. 12
   B. 10
   C. 11
   D. 24

79. For what class and group are receptacles, including attachment plugs, required to be listed when used in a hazardous location?
   A. Class 2, Group D
   B. Class 1, Group C
   C. Class 1, Group A
   D. Class 2, Group C

80. If a 60-amp receptacle and attachment plug are used above hazardous locations, the 60-amp plug is allowed to receive what listed amperage?
   A. 60 amps only
   B. 50 amps only
   C. Both 50 & 60 amps
   D. No special requirement

517.63 Grounded Power Systems in Anesthetizing Locations (A) Battery-Powered Lighting Units. One or more battery-powered lighting units shall be provided and shall be permitted to be wired to the critical lighting circuit in the area and connected ahead of any local switches.

517.63 Grounded Power Systems in Anesthetizing Location (B) Branch-Circuit Wiring. The branch circuits supplying only listed, fixed, therapeutic and diagnostic equipment, permanently installed above the hazardous (classified) location and in other-than-hazardous (classified) locations, shall be permitted to be supplied from a normal grounded service, single- or three-phase system, provided the following apply:

(1) Wiring for grounded and isolated circuits does not occupy the same raceway or cable.
(2) All conductive surfaces of the equipment are connected to an equipment grounding conductor.
(3) Equipment (except enclosed X-ray tubes and the leads to the tubes) is located at least 2.5 m (8 ft) above the floor or outside the anesthetizing location.
(4) Switches for the grounded branch circuit are located outside the hazardous (classified) location.

Exception: Sections 517.63(B)(3) and (B)(4) shall not apply in other-than-hazardous (classified) locations.
517.63 Grounded Power Systems in Anesthetizing Location (C) Fixed Lighting Branch Circuits. The branch circuits supplying only fixed lighting shall be permitted to be supplied by a normal grounded service provided the following apply:

(1) Such luminaries are located at least 2.5 m (8 ft) above the floor.
(2) All conductive surfaces of luminaries are connected to an equipment grounding conductor.
(3) Wiring for circuits supplying power to luminaries does not occupy the same raceway or cable for circuits supplying isolated power.
(4) Switches are wall-mounted and located above hazardous (classified) locations.

517.63 Grounded Power Systems in Anesthetizing Location (D) Remote-Control Stations. Wall-mounted remote-control stations for remote-control switches operating at 24 volts or less shall be permitted to be installed in any anesthetizing location.

517.63 Grounded Power Systems in Anesthetizing Location (E) Location of Isolated Power Systems. Where an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment. Isolated power system equipment and its supply circuit shall be permitted to be located in an anesthetizing location, provided it is installed above a hazardous (classified) location or in other-than-hazardous (classified) location.

517.64 Low-Voltage Equipment and Instruments. (A) Equipment Requirements. Low-voltage equipment that is frequently in contact with the bodies of persons or has exposed current-carrying elements to comply with one of the following:

(1) Operate on an electrical potential of 10 volts or less
(2) Be approved as intrinsically safe or double-insulated equipment
(3) Be moisture resistant

517.64 Low-Voltage Equipment and Instruments (B) Power Supplies. Power that is to be supplied to low-voltage equipment to comply with one of the following:

(1) An individual portable isolating transformer (autotransformers shall not be used) connected to an isolated power circuit receptacle by means of an appropriate cord and attachment plug
(2) A common low-voltage isolating transformer installed in other-than-hazardous (classified) location
(3) Individual dry-cell batteries
(4) Common batteries made up of storage cells located in other-than-hazardous (classified) location

517.64 Low-Voltage Equipment and Instruments (C) Isolated Circuits. Isolating-type transformers for supplying low-voltage circuits shall have both of the following:

(1) Approved means for insulating the secondary circuit from the primary circuit
(2) The core and case connected to an equipment grounding conductor

517.64 Low-Voltage Equipment and Instruments (D) Controls. Resistance or impedance devices shall be permitted to control low-voltage equipment but shall not be used to limit the maximum available voltage to the equipment.

517.64 Low-Voltage Equipment and Instruments (E) Battery-Powered Appliances. Battery-powered appliances shall not be capable of being charged while in operation unless their charging circuitry incorporates an integral isolating-type transformer.
517.64 Low-Voltage Equipment and Instruments (F) Receptacles or Attachment Plugs. Any receptacle or attachment plug used on low-voltage circuits to be of a type that does not permit interchangeable connection with circuits of higher voltage.

Informational Note: Any interruption of the circuit, even circuits as low as 10 volts, either by any switch or loose or defective connections anywhere in the circuit, may produce a spark that is sufficient to ignite flammable anesthetic agents.

### Exam Questions

**81.** How many battery powered lighting units are required in anesthetizing locations?
   - A. One
   - B. Three
   - C. Two
   - D. Five

**82.** How many provisions must be met for the branch circuits that supply fixed listed therapeutic equipment above hazardous locations so they can be supplied from a normal grounded service?
   - A. 3
   - B. 2
   - C. 4
   - D. 5

**83.** What is the maximum voltage where all wall-mounted remote-control stations for remote-control switches in anesthetizing locations can be installed in any location?
   - A. 28 Volts
   - B. 24 volts
   - C. 30 Volts
   - D. 36 Volts

**84.** What is isolated power system equipment required to be listed as?
   - A. Class 1 Division 2
   - B. Safety equipment
   - C. Isolated power equipment
   - D. Anesthetizing equipment

**85.** Which of the following is not a requirement for low voltage equipment that has exposed current-carrying elements in health care facilities?
   - A. Be moisture resistant
   - B. Operate on an electrical potential of 10 volts or less
   - C. Be listed and labeled as an exposed device
   - D. Be approved as intrinsically safe or double-insulated equipment

**86.** What is the core of an Isolation type transformers used for supplying low voltage circuits in health care facilities required to be connected to?
   - A. Delta windings
   - B. Wye windings
   - C. The center tap of B phase
   - D. Transformer Case

**87.** Resistance devices used in health care facilities are permitted to control equipment but are not permitted to limit the equipment's maximum allowable _______.
   - A. Line voltage
   - B. Load voltage
   - C. Low-voltage
   - D. Control voltage

**88.** Battery-powered appliances cannot be capable of being charged while in operation unless their charging circuitry incorporates what when used in health care facilities?
   - A. Integral isolating-type transformer
   - B. An AC inverter
   - C. Integral DC source
   - D. Grounding Electrode connection point

**89.** What are receptacles or attachment plugs used with low voltage equipment not permitted to interchange with in health care facilities?
   - A. Circuits of lower voltage
   - B. Non dedicated loads
   - C. Circuits of higher voltage
   - D. Non Transformed voltages specific to the equipment
517.71 Connection to Supply Circuit (A) Fixed and Stationary Equipment. Any fixed and stationary X-ray equipment shall be connected to the power supply by means of a wiring method complying with applicable requirements of Chapters 1 through 4 of this Code, as modified by this article.

Exception: Equipment properly supplied by a branch circuit rated at not over 30 amperes shall be permitted to be supplied through a suitable attachment plug and hard service cable or cord.

517.71 Connection to Supply Circuit (B) Portable, Mobile, and Transportable Equipment. Individual branch circuits shall not be required for portable, mobile, and transportable medical X-ray equipment requiring a capacity of not over 60 amperes.

517.72 Disconnecting Means (A) Capacity. The disconnecting means of adequate capacity for at least 50 percent of the input required for the momentary rating or 100 percent of the input required for the long-time rating of the X-ray equipment, whichever is greater, shall be provided in the supply circuit.

517.72 Disconnecting Means (B) Location. The disconnecting means shall be operable from a location readily accessible from the X-ray control.

517.72 Disconnecting Means (C) Portable Equipment. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding type attachment plug and receptacle of proper rating shall be permitted to serve as a disconnecting means.

517.73 Rating of Supply Conductors and Over current Protection (B) Therapeutic Equipment. The ampacity of conductors and rating of over current protective devices shall not be less than 100 percent of the current rating of medical X-ray therapy equipment.

Informational Note: The ampacity of the branch-circuit conductors and the ratings of disconnecting means and over current protection for X-ray equipment are usually designated by the manufacturer for the specific installation.

517.74 Control Circuit Conductors (B) Minimum Size of Conductors. Size 18 AWG or 16 AWG fixture wires as specified in 725.49 and flexible cords shall be permitted for the control and operating circuits of X-ray and auxiliary equipment where protected by not larger than 20-ampere over current devices.

517.75 Equipment Installations. All equipment for new X-ray installations and all used or reconditioned X-ray equipment moved to and reinstalled at a new location shall be of an approved type.

517.76 Transformers and Capacitors. Transformers and capacitors that are part of X-ray equipment shall not be required to comply with Articles 450 and 460. Capacitors shall be mounted within enclosures of insulating material or grounded metal.

517.77 Installation of High-Tension X-Ray Cables. Cables with grounded shields connecting X-ray tubes and image intensifiers shall be permitted to be installed in cable trays or cable troughs along with X-ray equipment control and power supply conductors without the need for barriers to separate the wiring.

517.78 Guarding and Grounding (A) High-Voltage Parts. All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high-voltage from the grounded enclosure. The connection from the high-voltage equipment to
X-ray tubes and other high-voltage components shall be made with high-voltage shielded cables.

517.78 Guarding and Grounding (B) Low-Voltage Cables. Low-voltage cables connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil-resistant type.

517.78 Guarding and Grounding (C) Non-Current-Carrying Metal Parts. Non-current carrying metal parts of X-ray and associated equipment (controls, tables, X-ray tube supports, transformer tanks, shielded cables, X-ray tube heads, etc.) shall be connected to an equipment grounding conductor in the manner specified in Part VII of Article 250, as modified by 517.13(A) and (B).

517.160 Isolated Power Systems. (A)(6) Wire-Pulling Compounds. Wire-pulling compounds that increase the dielectric constant must not be used on the secondary conductors of the isolated power supply.

**EXAM QUESTIONS**

90. X-ray equipment properly supplied by a branch circuit rated at not over ________ amperes is permitted to be supplied through a suitable attachment plug and hard service cable or cord.

A. 10  
B. 30  
C. 15  
D. 20