Electrical Level 4

Special Locations 26412-14

Objectives

When trainees have completed this lesson, they should be able to do the following:

1. Identify and select equipment, enclosures, devices, and wiring methods approved by the current *NEC*® for the following special occupancies or installations:
   - Places of assembly
   - Theatres
   - Carnivals, circuses, and fairs
   - Agricultural buildings
   - Marinas and boatyards
   - Temporary wiring
   - Office partitions
   - Swimming pools, fountains, hot tubs, and similar installations
   - Natural and manmade bodies of water
2. Comply with *NEC*® requirements regarding equipotential planes as they refer to bonding and grounding in water-related installations.
3. Determine electrical datum planes in water-related installations.

This is a knowledge-based module; there are no Performance Tasks.

Introduction; Assembly Occupancies

- Assembly occupancies are designed to hold more than 100 people and are covered in ***NEC Article 518.***
- Typical assembly occupancies include convention centers, churches, arenas, dance halls, auditoriums, cafeterias, and bus or train stations.

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Combination Civic Center/Chamber of Commerce Under Construction

- In some cases, an assembly occupancy may be attached to a building or other structure, such as the civic center/chamber of commerce shown here.
- Only the portion of the building designed to hold more than 100 people is covered by ***NEC Article 518***.

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MC Cable

- The building materials used in assembly occupancies must meet a specific fire rating to retard the spread of fire through adjacent spaces.
- Approved wiring methods include metal raceways, flexible metal raceways, nonmetallic raceways encased in 2" of concrete, mineral-insulated, metal-sheathed (MI) cable, metal-clad (MC) cable, or armored (AC) cable.

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Dining Facility in Assembly Occupancy

- Building codes often establish a finish rating for combustible supports used in the construction of assembly occupancies.
- The use of electrical non-metallic tubing and rigid nonmetallic conduit is restricted to club rooms, hotel conference/meeting rooms, courtrooms, dining facilities, restaurants, mortuary chapels, museums, libraries, and places of worship.

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Library

Where electrical nonmetallic tubing and rigid nonmetallic conduit is used in places of assembly, the raceways must be concealed in walls, floors, and ceilings that provide a thermal barrier with a finish rating of at least 15 minutes.

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Theaters and Similar Locations

- ***NEC Article 520*** covers indoor or outdoor spaces used for dramatic or musical presentations, motion picture projection, or similar purposes.
- This article also covers specific audience seating areas within motion picture or television studios.

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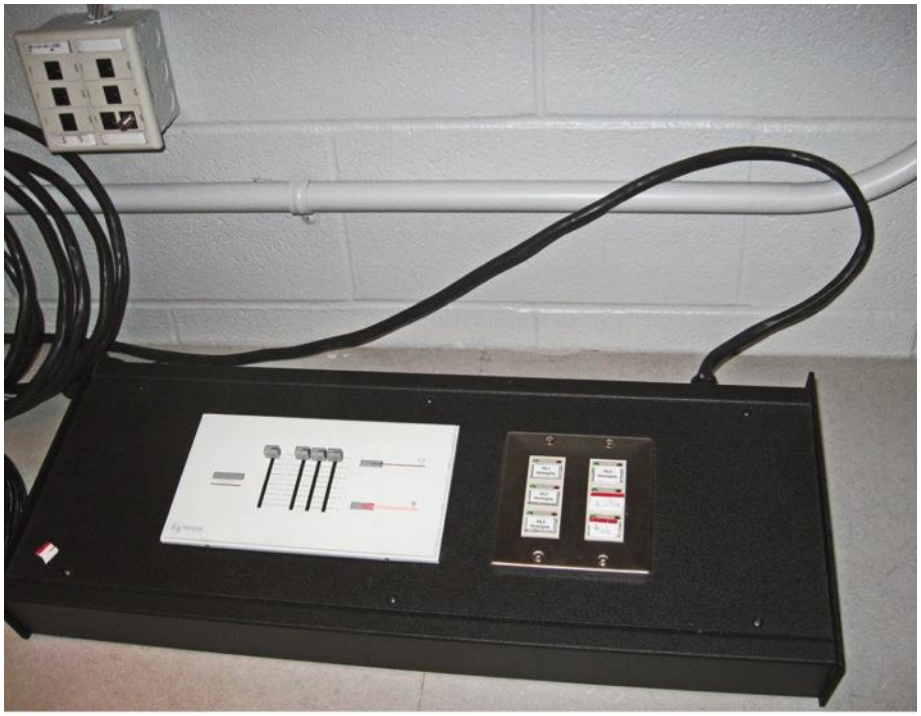
Portable Switchboard

- Theater wiring is covered in ***NEC Section 520.5***.
- Wiring for portable equipment such as portable switchboards, stage set lighting, and stage effects may be in the form of approved flexible cords/cables as long as the cords/cables are not fastened or secured by uninsulated staples or nails.



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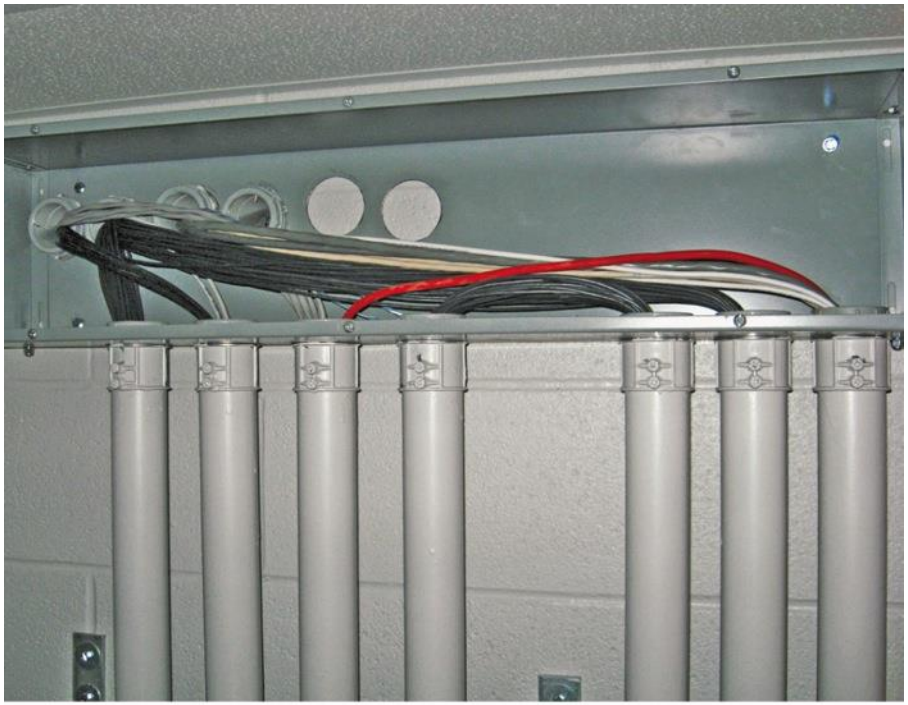
Gutter with More Than 30 Wires Installed in a Theater

- When conductors are installed in a gutter or wireway, the cross-sectional area of all conductors cannot exceed more than 20% of the gutter/wireway cross-section in which they are installed.
- If the number of conductors in an auxiliary gutter/wireway exceeds 30, derating is not required in theaters or audience areas.



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Switchboard Panel with Guard Grating in Place at the Top

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- Electrical equipment in theaters and similar areas is often operated by people with limited electrical training. Energized components must be enclosed or guarded to prevent shock.
- All switches must be designed for external operation only. Dimmers, rheostats, and similar devices must be installed in cabinets that enclose energized parts.

Fixed Stage Switchboard

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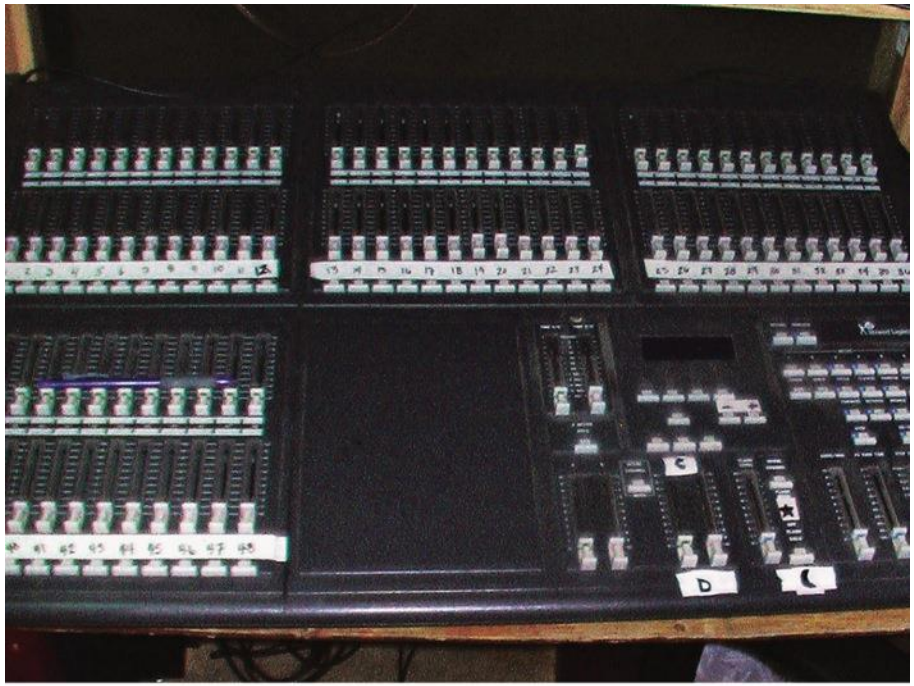
- Only dead-front switchboards may be installed in theaters and similar locations.
- Stage switchboard equipment that is designed with exposed electrical components on the back side of the board must be recessed in walls and covered by wire mesh grilles or other approved means.

Portable Resistance-Type Dimming Panel

- Stage/auditorium lighting dimmers may be designed to control voltage through either the grounded or ungrounded circuit conductor supplying the controlled lighting.
- When the ungrounded conductor is used, the dimmer must be protected by an overcurrent device with a rating no greater than 125% of the dimmer current rating.



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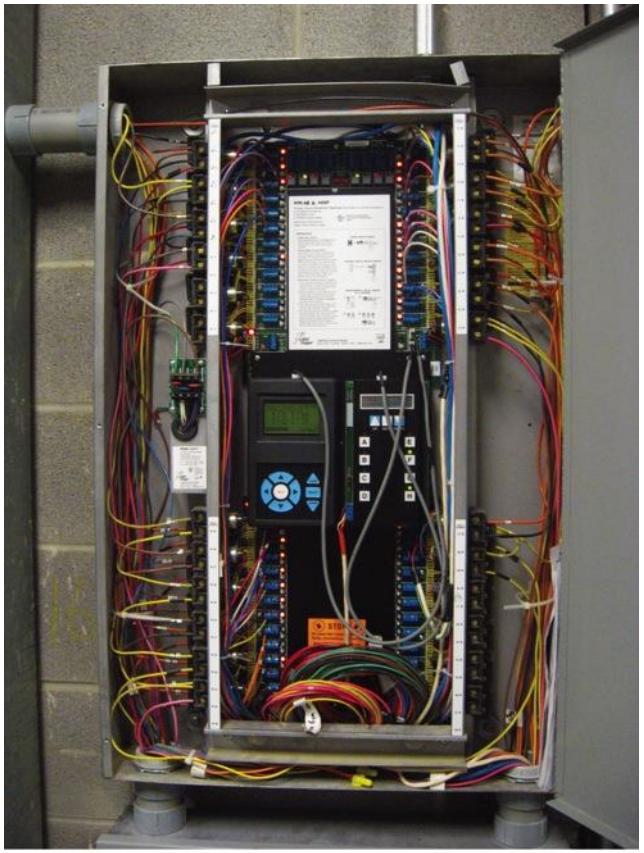
Fixed, Solid-State Programmable Dimming System



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- Solid-state dimmers may not be supplied with a voltage exceeding 150V between conductors unless rated for the voltage.
- When a grounded conductor is connected to a solid-state dimmer, the conductor must be common to both the input and output circuits. Connect the metal chassis to the equipment grounding conductor.

Manually Controlled Switchboard

- Stage switchboards may use manual, remote, or intermediate control, or any combination. Intermediate control uses primary and secondary switchboards, with the secondary switchboard functioning as a patch panel.
- In a manually controlled stage switchboard, all dimmers and switches are operated by handles linked to the control devices.

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Strip Lights

- Fixed stage equipment includes stage lighting, receptacles, connector strips, curtain machines, and smoke ventilators.
- Conductors that supply foot, border, proscenium, portable strip lights, and connector strips must have a minimum insulation temperature rating of 125° C; however, the 60° C column of ***NEC Table 310.15(B)(16)*** must be used when calculating ampacity.

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Ampacities of Listed Extra-Hard Usage Cords and Cables

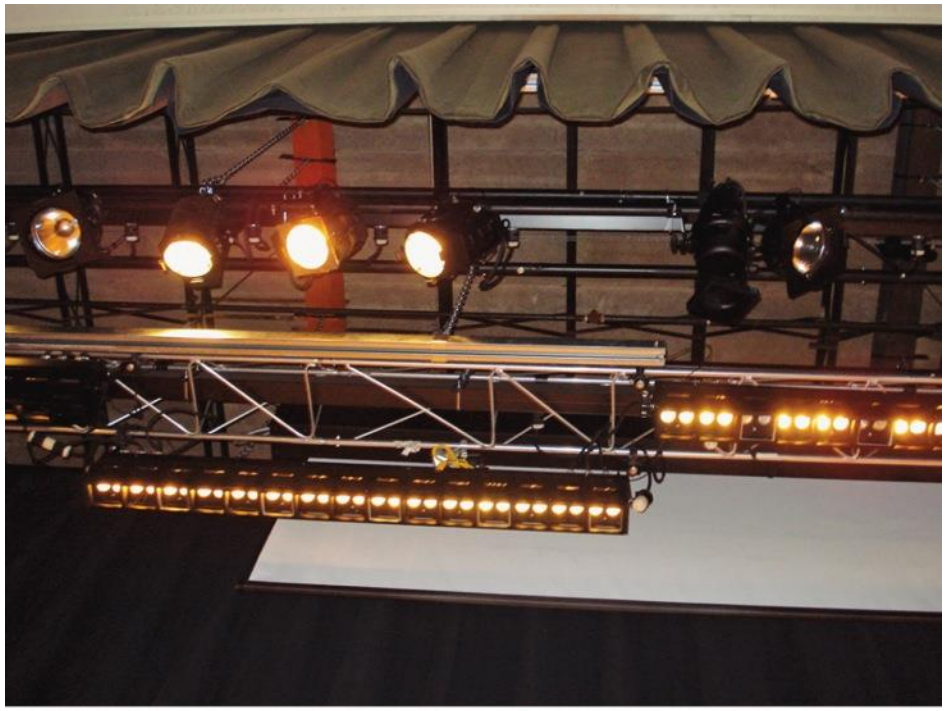
Size AWG	Temperature Rating of Cords and Cables 75°C	90°C	Maximum Rating of Overcurrent Device
14	24	28	15
12	32	35	20
10	41	47	25
8	57	65	35
6	77	87	45
4	101	114	60
2	133	152	80

Derating Factors for Extra-Hard Usage Cords and Cables

Number of Conductors	Percent of Ampacity
4–6	80%
7–24	70%
25–42	60%
43+	50%

Backstage Lighting

- Backstage lighting is usually utilitarian in design since it is out of view of the audience.
- When bare bulbs are used as backstage lighting, lamp guards must be installed with a minimum space of 2" between lamps and any combustible material.



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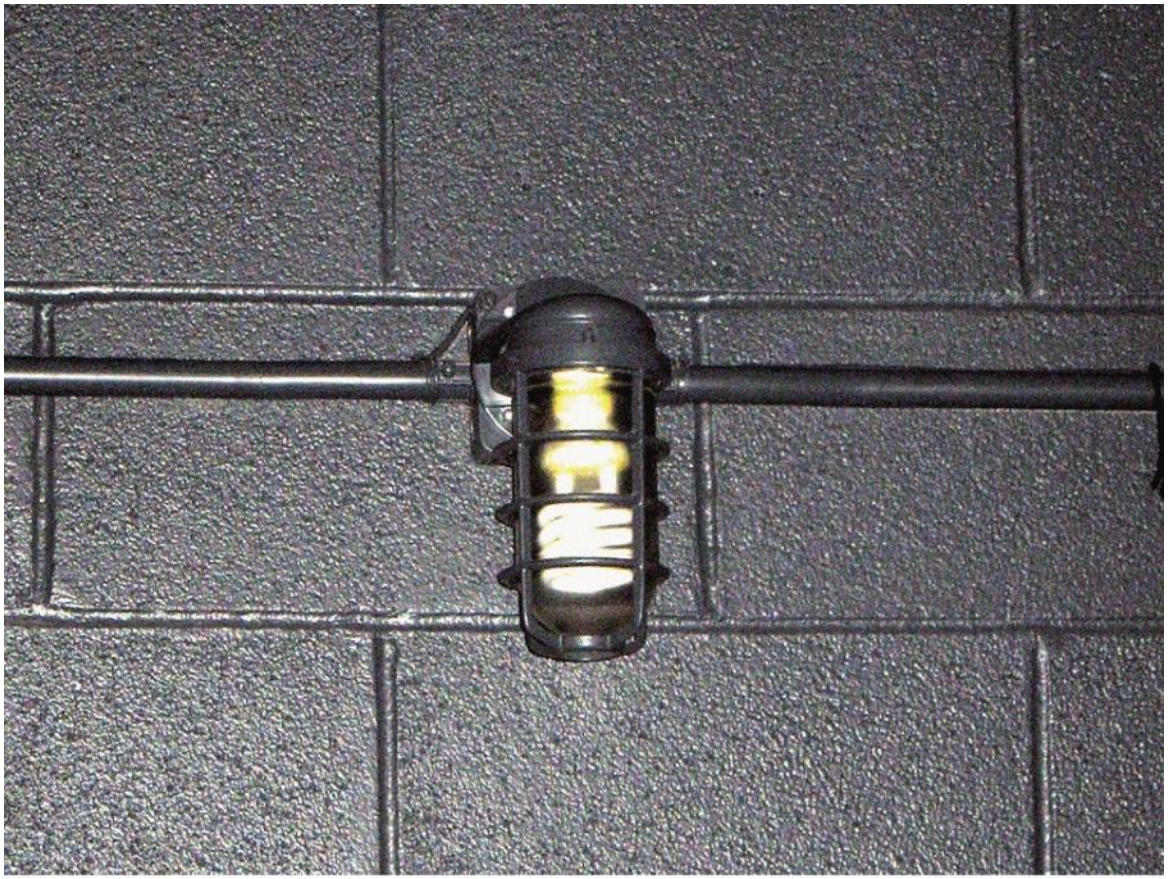
Lamp Guard



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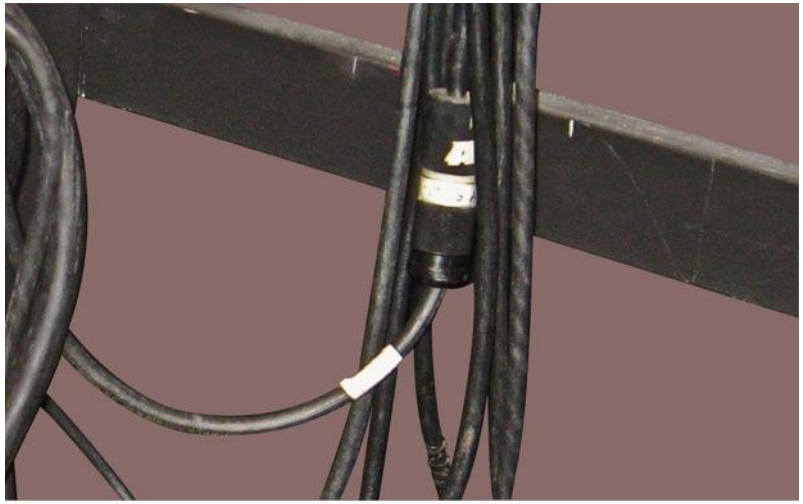
Properly Marked Grounded Conductor

- Equipment grounding and grounded (neutral) conductors must be marked in accordance with the *NEC*®. Neutral conductors that supply portable switchboards may be identified using white or gray marking 6" from each end of the conductor.
- Equipment grounding conductors are marked green or green with yellow stripes.



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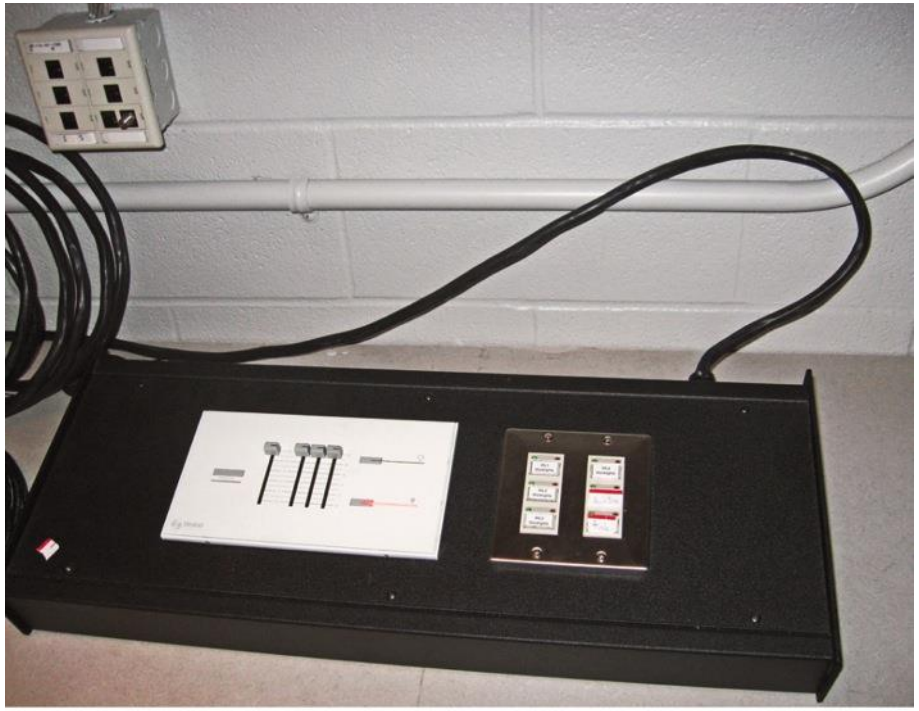
Portable Switchboard (Dimmer) Supplied by a Multiconductor Cord

- Portable switchboards must be installed in an enclosure that offers protection to the equipment and the general public.
- Each ungrounded conductor in every circuit supplied by the switchboard must have overcurrent protection.



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Next Session…

Carnivals, Circuses, Fairs, and Similar Events

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Carnivals, Circuses, Fairs, and Similar Events

- Carnivals, circuses, and fairs include large crowds, high power demands, outdoor installations, unpredictable animal behavior, and rapid setup and teardown of equipment.
- ***NEC Article 525*** lists the requirements for portable wiring associated with equipment and portable structures used in carnivals, circuses, fairs, and similar functions.

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Tents

- For portable structures, a clearance of 15' must be maintained from overhead conductors operating at 600V or less unless the conductors are supplying power to the structure.
- A portable structure may not be located under or within 15' of conductors with an energized voltage greater than 600V.

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Separately Derived Systems (Generators) Powering Portable Structures and Rides

- Service equipment must be mounted on a solid surface, protected from the weather, and lockable or located to prevent unauthorized access.
- If portable structures receive power from separately derived systems/different services and are less than 12' apart, all equipment grounding conductors must be bonded.

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Permanent Wiring on Amusement Rides

- Flexible cords/cables exposed to physical damage must be listed for extra-hard usage. If used outdoors, they must also be listed for wet locations and be sunlight resistant.
- Permanent wiring on portable amusement rides may use extra-hard usage flexible cords/cables where not exposed to physical damage.

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Disconnect Switch for Amusement Ride

- All rides and similar portable structures must be equipped with a disconnect switch within sight of the operator, no more than 6' away, and readily available at all times, even when the ride is running.
- If the disconnecting means is accessible to the general public, it must be lockable.

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Outlet Box for Concession

- Lamps that are part of portable lighting inside tents and concessions must be guarded.
- When outlet boxes or other device boxes are installed outdoors, the boxes must be weather-proof and mounted so the bottom of the box is at least 6" off the ground.

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First Disconnecting Means Supplied by a Generator at a Carnival

- The equipment grounding conductor must be connected to the system's grounded conductor at the service disconnect.
- In a separately derived system such as a generator, the equipment grounding conductor must be connected at the generator or in the first disconnecting means supplied by the generator.

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What's wrong with this picture?

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Agricultural Buildings

- ***NEC Article 547*** covers agricultural buildings, including all areas of poultry, livestock, and fish confinement systems.
- Boxes, fittings, and enclosures must be designed to minimize the entrance of dust, and listed for use in damp or wet locations where exposed to moisture or water.

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Totally Enclosed Motor

- ***NEC Section 547.7*** requires that all motors and rotating electrical machinery be totally enclosed or designed to reduce the entry of moisture, dust, or corrosive materials.
- Luminaires must be designed to minimize the entry of dust, moisture, or corrosive particles. Where luminaires are exposed to physical damage, guards must be installed.

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Agricultural Building Distribution Point

- Two or more agricultural buildings or structures located on the same premises may be electrically supplied from a single distribution point.
- If two or more buildings are supplied overhead from a distribution point, a site-isolating device must be installed.

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Next Session…

Marinas and Boatyards

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Marinas and Boatyards

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- ***NEC Article 555*** covers commercial and multifamily docking facilities, boatyards, boat basins, boathouses, and yacht clubs used for repairing, berthing, launching, storing, or fueling boats and/or the moorage of floating buildings.
- Docking facilities for single-family dwellings (houseboats) are not covered by ***NEC Article 555***.

Electrical Distribution System in a Marina

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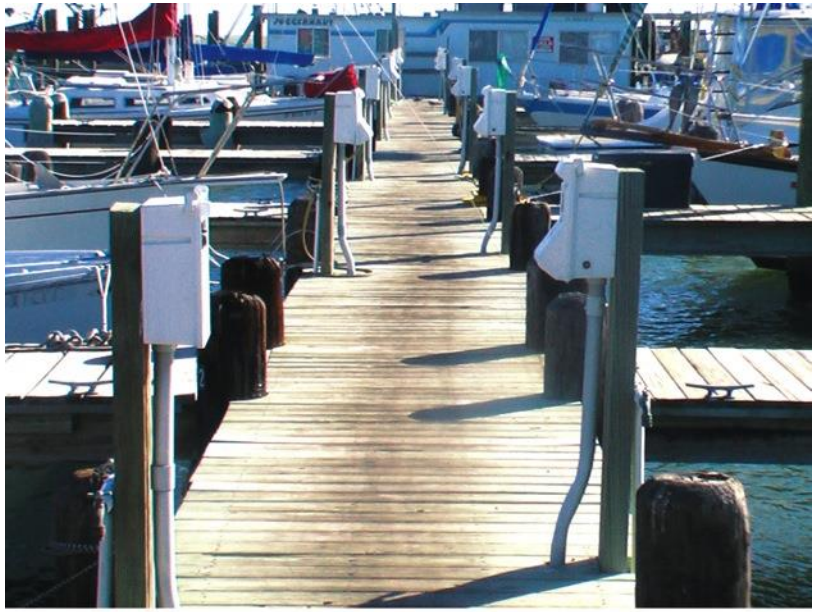
- Marine power outlets include any receptacle, circuit breaker, fused switch, meter, or similar device approved for marine use.
- Electrical distribution systems in boatyards and piers cannot exceed 600V phase-to-phase. Service equipment cannot be installed on or in a floating structure, and must be mounted adjacent to it.

Electrical Connections Within a Box Not Rated for Submersion Must be Mounted at Least 12 Inches Above the Deck



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- Electrical connections within boxes or enclosures that are not rated for submersion must be located at least 12" above the deck of a floating pier.
- Conduit may not be the sole support for electrical enclosures installed on piers above deck level. External box ears or lugs must be used for support.

Accessible Circuit Breakers in Watertight Enclosure

- Circuit breakers or switches installed in watertight enclosures must be operable without removing the enclosure cover.
- Watertight enclosures must include a weep hole to discharge condensation.

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Demand Factors

Number of Shore Power Receptacles	Factor Applied to the Sum of the Rating of the Receptacles
1–4	100%
5–8	90%
9–14	80%
15–30	70%
31–40	60%
41–50	50%
51–70	40%
71 and up	30%

Cable May be Used on Floating Sections of Piers

- When portable power cables are used as permanent wiring on the underside of piers, the cable must be rated for extra-hard usage, listed for wet locations, and sunlight resistant.
- Temporary wiring such as extension cords cannot be used to supply power to boats, piers, or other locations.

26412-14_F35.EPS

Masts and Lifts Must Clear Overhead Wiring

- The minimum overhead clearance for overhead wiring in boatyards and marinas is 18'.
- All electrical conductors and cables must maintain a minimum of 20' from the outer perimeter or any section of the boatyard that may be used to move vessels or for raising or lowering boat masts.

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Landing Stage Where People Access or Exit Boats

- Rigid metal or nonmetallic conduit must be installed above decks of piers and landing stages, and below the enclosure the landing stage serves.
- PVC must use threaded fittings to connect the conduit to the enclosure. All installations must be approved for damp or wet locations.

26412-14_F37.EPS

Watertight Shore Power Enclosure with Accessible Circuit Breakers

- A disconnecting means must be provided for each shore power receptacle and must be located within 30" of the receptacle.
- Receptacles must be mounted at least 12" above the deck surface of the pier and not below the electrical datum plane on a fixed pier.

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GFCI-Protected Receptacle on Non-Shore Power Receptacle Installed Outdoors on Pier

- Marina receptacles can be either shore power receptacles or non-shore power receptacles.
- Shore power receptacles must be rated at no less than 30A, listed as marina power outlets, and installed in weatherproof enclosures. Strain relief must be provided.
- Non-shore power receptacles must be labeled and provided with GFCI protection.

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What's wrong with this picture?

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Class I, Division 1 Area Below Fuel Dispenser in the Void Between the Pier and the Water

- Areas in and around fuel dispensing locations are classified as either Class I, Division 1 or Class I, Division 2.
- Class I, Division 1 locations include voids, pits, or similar areas below closed-construction floating docks, piers, or wharfs supporting fuel dispensers in which flammable liquid or vapor can accumulate.

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Next Session…

Docks or Sections of Pier that Abut this Fuel Dispensing Pier are Classified as Class I, Division 2

- Class I, Division 2 locations include spaces above the surface of closed-construction floating docks, piers, or wharfs that are within 18" of the dispenser enclosure.
- Sections of a dock, pier, or wharf that directly abut the fuel dispensing pier are also considered Class I, Division 2.

Temporary Installations

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Temporary Installations

- Temporary wiring includes wiring used to supply temporary power and lighting to construction sites, and for remodeling, maintenance, repair, demolition, holiday decorative lighting, electrical tests, emergencies, experiments, and developmental work.
- The requirements for temporary wiring are covered in ***NEC Article 590***.

26412-14_F42.EPS

Holiday Lighting

- Holiday lighting may be supplied by single insulated branch circuit conductors operating at no more than 150V if protected against physical damage and the conductors are supported on insulators no more than 10' apart.
- Lighting hung in festoon (swag) fashion must be arranged to avoid conductor strain at the lampholder.

26412-14_F43.EPS

Lamp Guard in Place on Temporary Lighting at a Construction Site

- General illumination luminaires must be designed to protect the lamp from contact or breakage.
- All exposed lamps must be equipped with a lamp guard. Brass lamp shells, paper-lined sockets, or other metal-cased sockets may not be installed unless the lamp shell is grounded.

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Receptacles on a Construction Site Must be GFCI-Protected

- Ground fault protection must be provided on all 125V, single-phase, 15A, 20A, or 30A temporary receptacles that are not part of the permanent wiring.
- If a receptacle that is part of the permanent wiring is used for temporary power, it must also be GFCI-protected.

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Wired Partitions

- Wired partitions allow for convenient rearrangement of office spaces.
- ***NEC Article 605*** provides the requirements for lighting accessories and wired office partitions.

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Next Session…

Swimming Pools, Fountains, Hot Tubs, and Similar Installations

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Swimming Pools, Fountains, Hot Tubs, and Similar Installations

- ***NEC Article 680*** covers the wiring and equipment for permanently installed swimming pools, storable pools, spas and hot tubs, fountains, therapeutic tubs and tanks, and hydromassage bathtubs.
- Because of the proximity to water, all electrical equipment in a pool area must be grounded.

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Fountain

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Panel in Equipment Room of Swimming Pool

Equipment and devices that require grounding include underwater and through-wall luminaires, electrical equipment located within 5' of the inside wall of the body of water, water-circulating equipment, junction boxes, transformer enclosures, GFCIs, and panel-boards supplying associated equipment.

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Overhead Conductors Near a Community Swimming Pool

- The required clearances between open overhead electrical conductors and the water's edge are listed in ***NEC Table 680.8***.
- The overhead conductors shown here operate at about 750V near a community swimming pool.

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Overhead Conductor Clearances

Parameters	Insulated Cables Supported By a Solidly Grounded Bare Messenger Wire or Grounded Neutral Conductor	Conductors Not Insulated or Supported by Solidly Grounded Bare Messenger Wire or Grounded Neutral Conductor	
	0–750V to Ground	0–15kV	Over 15KV–50kV
A. Clearance in any direction to the water level, edge of water surface, base of diving platform, or permanently anchored raft	22.5 feet	25 feet	27 feet
B. Clearance in any direction to observation stands, towers, or diving platform	14.5 feet	17 feet	18 feet
C. Horizontal limit measured from the inside wall of the pool	Must extend to the outer edge of all structures described in A and B but not less than 10 feet.		

Minimum Cover Depths

Wiring Method	Minimum Depth in Inches
Rigid Metal Conduit	6
Intermediate Metal Conduit	6
Nonmetallic Conduit Listed for Burial Under 4" Concrete Min.	6
Nonmetallic Direct Burial Conduit	18
*Other Approved Raceways	18

*Other approved raceways requiring concrete encasement for burial must have a concrete envelope no less than 2 inches thick.

Service and Disconnecting Means for the Pool Equipment

- A disconnecting means that simultaneously disconnects all ungrounded conductors must be provided for all utilization equipment other than lighting.
- The disconnecting means must be in a readily accessible location at least 5' horizontally from the inside wall of a pool, hot tub, or spa unless a barrier is permanently installed.

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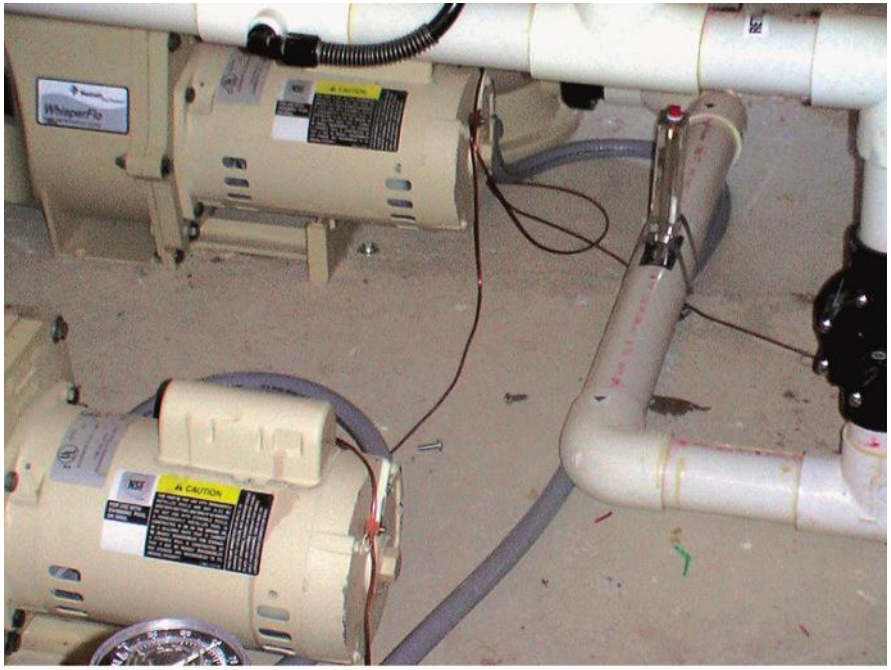
Pool Recirculation Motors Connected with Liquidtight Flexible Metal Conduit

- When flexibility is necessary due to motor vibration, the motor connection must be made using liquidtight flexible metal or liquidtight flexible nonmetallic conduit.
- Cord-and-plug connections are permitted as long as the cord is no longer than 3' and incorporates an equipment grounding conductor terminated in a grounding-type plug.



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Pole-Mounted Area Lighting Around a Pool

- Area lighting includes all lighting around or above pool areas except those luminaires installed in or under water.
- New luminaires, lighting outlets, or paddle fans above outdoor pools or within 5' horizontally from the inside walls must be installed no less than 12' above the maximum water level.

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Low-Voltage Area Lighting Around a Pool

Luminaires located within 16' of the pool and powered by cord-and-plug connections must comply with the cord-and-plug requirements of ***NEC Section 680.22(B)(5)***.

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Spa Emergency Shutoff Switch and Adjacent Timer

- Switches must be located at least 5' from the pool's edge unless separated by a solid fence, wall, or other permanent barrier, or the switch is listed for use within 5' of a pool.
- A spa timer and emergency shutoff switch are shown here.

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GFCI Circuit Breaker Supplying the Underwater Luminaire

- To prevent shock during relamping, any underwater luminaire that operates at more than 15V must have a GFCI installed in the branch circuit supplying the luminaire.
- Underwater luminaires supplied by a transformer and operated at less than 15V do not require ground fault protection.

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Plated Copper Forming Shell

- A wet-niche luminaire is mounted in a forming shell that provides a conduit connection.
- All metal parts of the luminaire and forming shell that come in contact with the water must be made of brass or other approved corrosion-resistant metal.

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Sufficient Cord Must be Provided to Allow the Luminaire to be Relamped Without Entering the Water

- Wet-niche luminaires must be secured and bonded to the forming shell using a positive locking device that requires a wrench or other tool to remove.
- The cable or cord must allow for luminaire removal and placement on the deck/other dry location without requiring the electrician to enter the water.

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Junction Box Supplying Wet-Niche Luminaire

- Junction boxes must be corrosion-resistant, use threaded or nonmetallic hubs, and provide electrical continuity between all metal conduit connections and the grounding terminals.
- For luminaires operating at more than 15V, the junction box must be mounted at least 4" above ground or at least 8" above the maximum water level.

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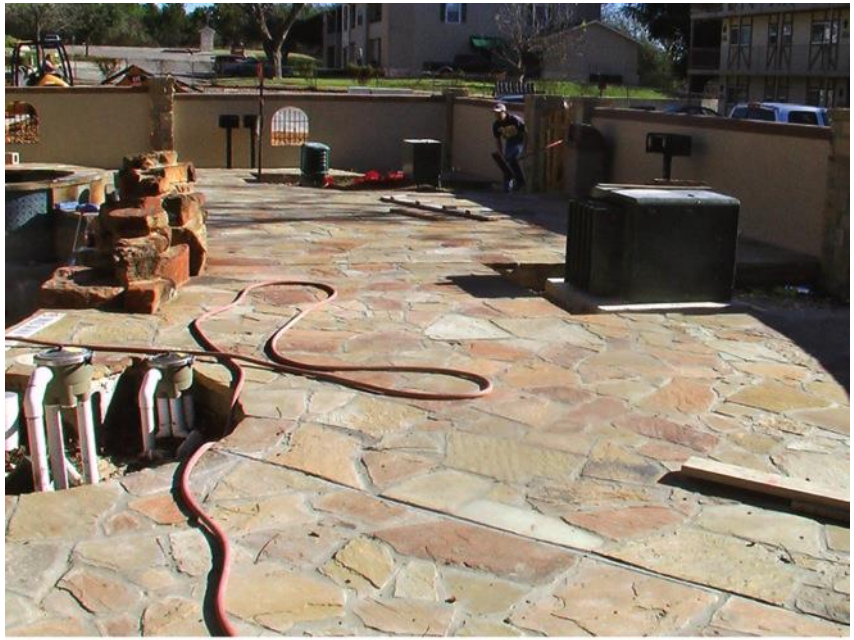
Pool Perimeter Conductive Surfaces



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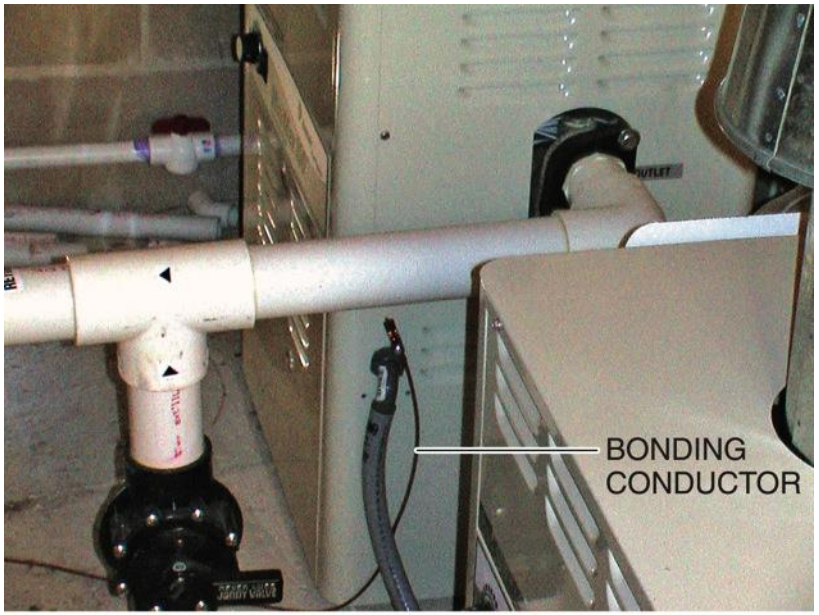
- Equipotential bonding in pools and fountains is the interconnection of all noncurrent-carrying conductive parts and surfaces (not just metal), with an approved grounded bonding conductor to reduce any voltage gradients.
- The bonding conductor must be solid copper, insulated or bare, and no smaller than No. 8 AWG.

Pool Heater Bonded to the Equipotential Bonding System



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- All conductive pool shells and pool perimeter surfaces must be included in the equipotential bonding system.
- Follow the manufacturer's recommendations regarding grounding and bonding of pool water heaters.

Storable Pool

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- Cord-connected storable pool filter pumps must be double-insulated and have any internal, nonaccessible, noncurrent-carrying metal parts grounded using an equipment grounding conductor.
- The attachment plug must be designed with integral GFCI protection or the power supply cord must incorporate GFCI protection within 12" of the attachment plug.

Spa Emergency Shutoff Switch Located at Least 5 Feet from Spa

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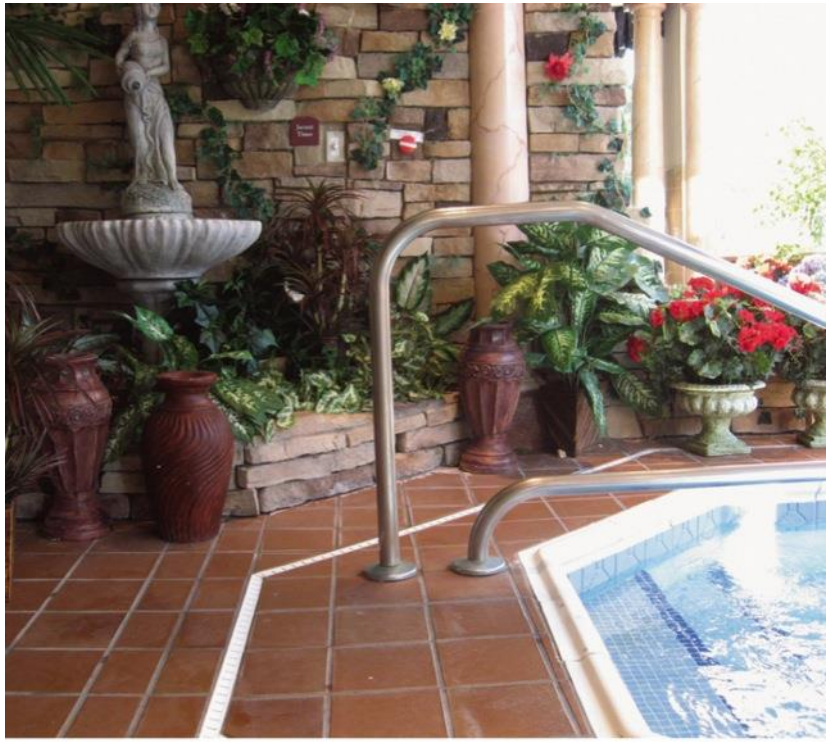
- Except in single-family dwellings, all spas and hot tubs must include a clearly labeled emergency shutoff or control switch that controls power to the recirculation and/or jet system motor.
- The emergency shutoff must be readily accessible but no less than 5' away from the spa/hot tub.

Spa Handrails Must be Bonded

- All metal fittings, noncurrent-carrying metal parts of electrical equipment, and any metal raceway, piping, or surface within 5' of the inside walls of a spa or hot tub, unless separated by a permanent barrier, must be bonded.
- Any electrical device or control not associated with the spa or hot tub, but located within 5' of it, must also be bonded.



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Permanently Installed Fountain

Permanently installed fountains, ornamental pools, display pools, and reflection pools must comply with ***NEC Article 680, Parts I and V***.

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Fountain Using Pool Water

Fountains that use common water from a swimming pool must also comply with ***NEC Article 680, Part II***.

26412-14_F67.EPS

Next Session…

Natural and Manmade Bodies of Water

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Natural and Manmade Bodies of Water

Natural bodies of water include lakes, streams, ponds, and rivers, all of which may naturally vary in depth.

26412-14_F69.EPS

Next Session…

- Manmade bodies of water refer to aeration ponds, fish farm ponds, storm retention basins, water treatment ponds, and irrigation channels.
- Electrical installations in and around natural and manmade bodies of water are covered in ***NEC Article 682***.

Wrap Up

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Wrap Up

3-2-1

3 – Write 3 important things learned during class

2 – Write 2 questions you have about the material

1 – Write 1 thought you had about the material

Next Session…

MODULE EXAM

Review the complete module to prepare for the module exam. Complete the Module Review as a study aid.