NEC Article 620: Elevators, Part I

by David Herres

photos by Judith Howcroft

Learning Objectives

After reading this article, you should have learned about:

- ♦ The meanings of definitions for control room and control space versus machine room
- ♦ The purpose and specifications for working spaces
- ♦ Insulation types and minimum sizes of conductors
- ♦ Requirements for feeder and branch-circuit conductors
- ♦ Feeder demand factors for elevators

We generally think of the 19th century as the great age of building codes. A surge of immigration to the U.S., the end of slavery and, on both sides of the Atlantic Ocean, a burgeoning industrial revolution ignited an acceleration in new building. Building codes were deemed necessary to protect the public against shoddy builders and outmoded construction techniques. But, building codes had been in existence for many centuries.

Hammurabi, sixth king of Babylon and creator of the Babylonian Empire, decreed:

> *"If a builder builds a house for someone and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death. . . . If it kills the son of the owner, the son of that builder shall be put to death."*

If we fast forward more than 36 centuries, we see some important new developments in elevator technology. Elisha Otis' safety elevator, introduced in 1853, prevented the fall of the car if the cable broke. A few years later, in 1880, Werner von Siemens built the first electric elevator, setting the stage for a new industry that would change the world by making the practical use of tall buildings possible.

For all of this to come together in the real world, there had to be some assurance that these new technologies could be used safely on a wide scale. Later in the 19th century, Thomas Edison and his associates built an electrical distribution system in Lower Manhattan. Even though Edison grasped the basic ideas of fusing and overcurrent protection, many hazards remained. Finally, in 1897, the first National Electrical Code (NEC) appeared. The main impetus for the creation of the NEC in the closing years of the 19th century was the collective anguish experienced by insurance underwriters who were losing vast amounts of money due to liability and physical damage claims resulting from Edison's electrification of, first, Lower Manhattan and then the world. Through numerous editions, the NEC has, to a great extent, mitigated the hazards accompanying widespread use of electricity, particularly with respect to elevator technology.

NEC Article 620 covers elevators, dumbwaiters, escalators, moving walks, platform lifts and stairway chairlifts. Each of these performs a different function, and the wiring mandates vary accordingly. The most complex of these is the elevator.

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Value: 1 contact hour (0.1 CEU)

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When you consider that an elevator is an enclosed room with one or more doors that people voluntarily enter so they may travel hundreds of feet up or down, several observations are in order. Weight (passengers, freight, car and attendant machinery) may be fairly substantial, and speed is significant. Many undertake trips in these devices two or more times daily in full confidence that they will survive an uneventful experience with a minute chance of disaster or even inconvenience. Elevator travel is far safer than an automobile trip, and the chance of experiencing disaster is on the order of being struck by lightning in one's own backyard. Indeed, most elevator accidents involve maintenance workers, yet even theirs is not an excessively dangerous profession.

Part of the reason that elevator usage is extraordinarily safe is that construction and maintenance are regulated by the wonderfully robust *ASME A17.1 2007/CSA B44-07 Safety Code for Elevators and Escalators*, which contains overall construction and maintenance requirements –everything from seismic mandates to machine-room lighting. A little more narrowly focused (yet of great consequence) is the ubiquitous NEC, which, in the National Fire Protection Association (NFPA)'s venerable Handbook edition, devotes 18 double-column pages to electrical design and installation requirements for elevators, escalators and related equipment. These requirements, found in Article 620 (part of Chapter 6, Special Equipment), are in addition to NEC Chapters 1-3, which stipulate general wiring protocols applicable in most residential, commercial and industrial venues.

The code exempts some fairly broad areas where compliance is not expected. For example, wiring that is under exclusive utility control and has to do with the generation and distribution of electrical power is not NEC regulated. Here, the National Electrical Safety Code has jurisdiction. Utility-owned electrical structures not directly concerned with electrical generation, transmission and distribution are NEC regulated. An example would be the elevator, as well as all wiring in a utility-owned administration building. Similarly, underground wiring in mines is not NEC regulated, although other, non-mine wiring below ground (such as lighting in an underground traffic tunnel) is covered. The electrical conductors and equipment for non-mine elevators that extend below grade are under NEC jurisdiction.

It is also worth mentioning that the stated purpose of the NEC is the practical safeguarding of persons and property from hazards arising from the use of electricity. The two primary hazards are fire and electric shock or arc flash, although there are others. For example, an inadequately supported ceiling fan could fall and cause injury or property damage. The code is not concerned with the

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efficiency or sophistication of equipment that it covers, except insofar as safety (in terms of human injury and property damage) is concerned.

Many professionals believe the NEC is applicable only for voltages over a certain level, but that is not the case. Even non-composite fiber-optic cable, which does not carry electrical energy, is subject to the code. This is because the material may contribute fuel to a fire that has originated elsewhere. The fire loading resulting from an accumulation of abandoned low-voltage cabling may be considerable, and has to be understood and dealt with. This is especially true in an elevator shaft where measures have to be taken to ensure that a hazardous situation is not created.

We shall now take a look at the principle requirements of Article 620, with particular emphasis on wiring requirements for elevator shafts, machine rooms and cars. NEC articles generally adhere to a template, which greatly aids in navigating and quickly locating mandates as needed for project design or, on an installation level, in the field. Article 620 follows this pattern by opening, in Section I, General, with a statement of scope and definitions applicable to the topic under consideration. It is noted that the article covers the installation of electrical equipment and wiring for elevators, dumbwaiters, escalators, moving walks, platform lifts and stairway chairlifts. This is somewhat broader than A17.1-2007/B44-07. Nevertheless, the primary NEC focus is on elevators, and the intention is to mitigate the hazards associated with the use of electricity. (ASME has a separate document, *A18.1-2008 Safety Standard for Platform Lifts and Stairway Lifts*). NEC has a further note that the term "wheelchair lift" has been changed to "platform lift."

Article 620's "Definitions" section includes two terms that describe spaces not attached to the outside of a hoistway. These are: remote machine room and control room (for elevator and dumbwaiter), and remote machinery space and control space (for elevator and dumbwaiter). They are differentiated from other similar structures by the fact that they are not attached to the outside perimeter or surface of the walls, ceiling or floor of the hoistway. In a time when increasing value is placed on even small amounts of real estate, elevator design must strive to configure, efficiently control and drive elements to whatever degree possible, and that is the thinking behind some alternate locations for these structures.

Such design innovations require sophisticated wiring strategies. Traditional wiring methods and materials come into play, as always, but it is necessary to rethink their deployment. The 12 definitions provided in NEC 2011, Section 620.2 are the place to start for guidance in this

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area, and the sections that follow lay out implementation guidelines that are very relevant in today's environment. It is worth noting that these NEC terms, used throughout Article 620, have been chosen to correlate with A17.1-2007 usage. The two documents are in harmony and should be used in conjunction.

Other terms defined in NEC Article 620 are Control System, Motion Controller, Motor Controller, Operation Controller, Operating Device and Signal Device. While the definitions are straightforward, their deployment in real-life building projects involves enormous legal and moral implications, given the fact that we are carrying large numbers of people hundreds of feet above the earth's surface on a daily basis.

Many NEC articles address voltage limitations, and Article 620 is no exception. Generally, it is decreed that the supply voltage is not to exceed 300 V between conductors (allowing for the familiar 240-V concept), although there are exceptions. You may go up to 600 V for power circuits supplying door-operator controllers and door motors, branch circuits and feeders to motor controllers, driving-machine motors, machine brakes and motor-generator sets. It is worth mentioning that when 600 V is talked about as a limit in the NEC, it is generally meant that the familiar 600-V nominal-voltage system is considered to lie within the permitted zone, making it a common usage.

It is further stipulated that internal voltages of power-conversion equipment and functionally associated equipment, and the operating voltages of wiring interconnecting the equipment, are permitted to be higher, provided that the equipment and wiring are listed for the higher voltages. Where voltages exceed 600, a sign reading "DANGER – HIGH VOLTAGE" is required. Heating and air-conditioning equipment located on the car must not be in excess of 600 V. All live parts of electrical apparatuses are to be enclosed to protect workers and the public against accidental contact.

Working spaces for electrical equipment that may have to be examined, adjusted, serviced or maintained is required in all occupancies in an earlier NEC section, 110.26(A). This requirement applies to all controllers, disconnecting means and other electrical equipment that may need servicing, inspection or maintenance. The main concern is to ensure that workers may escape to safety in the awful circumstance of an arc-fault event.

The usual scenario for electrical injury is shock – when electrical current passes through the human body. A different occurrence involves exposure to the explosive blast when there is a line-to-line or line-to-ground arc blast. The electrical energy does not traverse the human body, but proximity to the explosion means severe injury is possible from the intense heat and concussive shockwave. After such an event, it is important that the affected worker is able to escape the area and get to help. For this reason, the NEC provides for adequate working space around electrical equipment that may need to be serviced. The basic requirement is for minimum clear distances of various depths for equipment operating at 600 V or less, nominal, depending upon voltage to ground and lateral distance to insulated or grounded surfaces or exposed live parts (not an issue in elevator machine rooms). This clear working space must be 30 in. wide or the width of the equipment, whichever is greater. It need not be exactly centered on the equipment, and working spaces of adjacent pieces of equipment may overlap. In all cases, the working space must permit at least a 90° opening of equipment doors or hinged panels.

As for height, the working space must extend from the grade, floor or platform to 6-1/2 ft. or the height of the equipment, whichever is greater. Additional requirements concern escape routes. A second door is required if the equipment is rated over 1200 amps and over 6 ft. wide. Doors must open in the direction of travel and be equipped with panic bars, pressure plates or other devices that are normally latched but open under simple pressure. The thinking behind this requirement is that the injured worker could have severe hand burns and be unable to operate a conventional doorknob. In an elevator machine room, where space may be limited in the first place, the working-space mandate must be factored in very early in the design process lest an unthinkable amount of rework be necessary. Moreover, it is necessary to consider future worker safety for an indefinite period.

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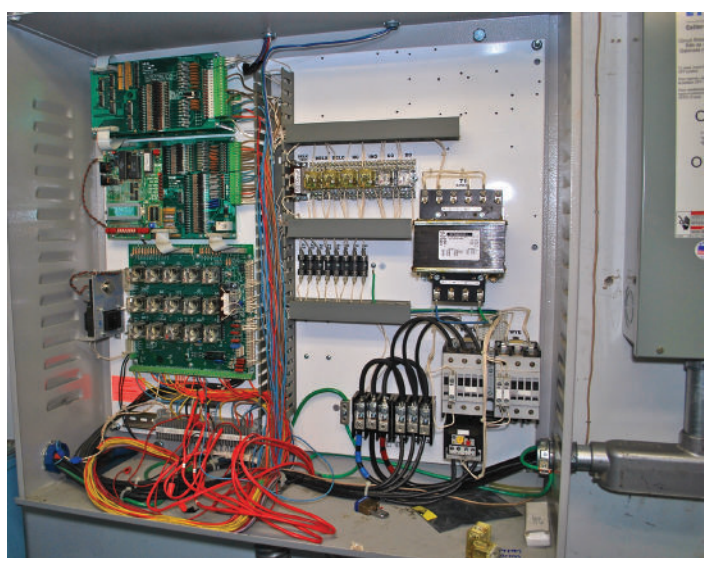

Interior of an elevator motor controller: the motor circuit conductors are the heavy wires at lower right. To the left are printed circuit boards with microprocessors that govern elevator performance.

Power coming into the machine room with a ground-fault circuit interrupter-protected receptacle on a dedicated circuit as required.

Part II of Article 620 concerns conductors used in elevator work, and several important requirements are covered. Hoistway door interlock wiring from the riser must be flame retardant and have insulation suitable for a temperature not less than 200°C (392°F), much higher than that required for most raceway or cable applications. Thus, the need for door interlock functionality is recognized.

Similarly, the integrity of the traveling cable is emphasized. Acceptable types of wire for this application are given in Table 400.4, which occurs in an earlier chapter and lists various types of elevator cable for lighting and control in both unclassified and hazardous locations. NEC 2011 Article 620.21(2)(b) states that hard-service cords and junior hard-service cords that conform to the requirements of Article 400 (Table 400.4) are permitted as flexible connections between the fixed wiring on the car and devices on the car doors or gates. ("Hard-service" and "junior hard-service" are trade names that apply to over 30 types of flexible cord, all beginning with the letter S. They have varying properties, such as oil resistance, and various material compositions for insulation, such as a thermoplastic elastomer. Many of these are for portable lighting.)

To achieve flexibility and endurance, traveling cable is more finely stranded and, where possible, separated into discrete conductors. One way to achieve this is by paralleling wires, i.e., connecting the runs at both ends so they are physically like two wires but electrically one. This strategy works to improve the flexibility of the traveling cable, but it is contrary to a general NEC rule concerning the paralleling of conductors, which is generally done in very large sizes to avoid unwieldy wire pulls and terminations. In driving through commercialized suburban areas, you frequently see paralleled conductors for large retail grocers (where there is a heavy refrigeration load). The NEC rule specifies that the minimum size for paralleled conductors is 1/0 AWG, which is much too big for an elevator traveling cable. Accordingly, for this application, the minimum size is reduced to 20 AWG for lighting circuits.

Feeder and branch-circuit conductors are required to have specified ampacities:

- Conductors supplying a single motor are to have an ampacity not less than the percentage of motor nameplate current determined from Section 430.22(A) and (E). Elevator motors are inherently intermittent duty. Moreover, because motors have a higher starting current than other loads, the overcurrent protection protocol is unique to them and somewhat counterintuitive. If the entire feeder/branch circuit assembly were to be protected in the conventional manner, the motor would cut out long before reaching operating speed. Accordingly, the supply wires are protected only for short circuit, and the overload protection is provided closer to the motor.
- Conductors supplying a single motor controller are to have an ampacity not less than the motor controller nameplate current rating plus all other connected loads.

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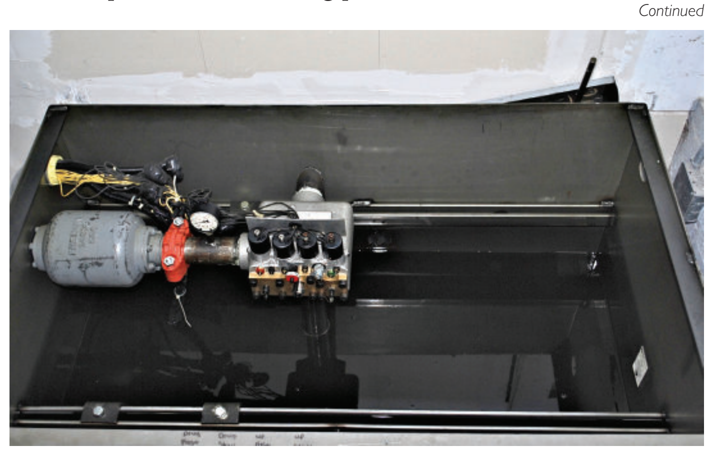

Hydraulic reservoir characteristic of a hydraulic-piston-operated elevator. With heavy use on a hot day, the oil can overheat, causing elevator shutdown. This may be countered by providing good machine-room ventilation. The fan should be on a dedicated circuit.

- Conductors supplying a single power transformer are to have an ampacity not less than the nameplate current rating of the power transformer plus all other connected loads.
- Conductors supplying more than one motor, motor controller or power transformer are to have an ampacity not less than the sum of the nameplate current ratings of the equipment plus all other connected loads.

Feeder conductors of less ampacity are permitted for group installations and quite common in elevator work. The demand factors are given in Table 620.14, which allows significant reductions as the number of motors is increased. The demand factor ranges from 1.00 for one elevator on a single feeder to 0.72 for 10 or more elevators on a single feeder. The idea is quite simple. As greater numbers of elevators are added, the likelihood of them all operating simultaneously decreases so that it is permissible to reduce the feeder ampacity.

Number of Elevators	Demand on a Single Feeder Factor
1	1.00
2	0.95
3	0.90
4	0.85
5	0.82
6	0.79
7	0.77
8	0.75
9	0.73
10 or more	0.72

Table 620.14: Feeder Demand Factors for Elevators

Part III, Wiring, looks at the types of wiring that may be installed in hoistways, cars, machine rooms and related spaces. The basic wiring methods are rigid-metal, rigid nonmetallic or intermediate-metal conduit; electrical metallic or rigid nonmetallic tubing; wireways; or Type MC, MI or AC cable, unless otherwise permitted. The traveling cable, of necessity, is exempted.

Three wiring categories within hoistways are allowed in addition, each with exceptions. Cables used in Class 2 power-limited circuits are permitted between risers and signal equipment and operating devices, provided they are supported and protected from physical damage and are of the jacketed and flame-retardant type. Flexible cords and cables part of listed equipment operating at 30 V (42 VDC) or less, similarly supported and protected, jacketed and flame retardant, are permitted. In hoistways not longer than 6 ft., these additional wiring methods are permitted:

- Flexible metal conduit
- Liquid-tight flexible metal conduit
- Liquid-tight flexible nonmetallic conduit
- Flexible cords and cables, or conductors grouped together and taped or corded, are permitted without raceway, where they are part of listed equipment, a driving machine or a driving-machine brake

A sump or oil-recovery pump located in the pit is permitted to be cord connected. The cord is to be a hard-usage, oil-resistant type not over 6 ft. in length. Within cars, these additional wiring methods are permitted:

- Flexible metal conduit, liquid-tight flexible metal or nonmetallic conduit, 3/8 in. or larger, not over 6 ft. in length
- Hard-service cords and junior hard-service cords are permitted as flexible connections between the fixed wiring on the car and devices on the car doors or gates. Hard-service cords are permitted only as flexible connections for the top-of-car operating device or the car-top work light.

The following additional wiring methods are permitted on the car assembly in lengths not exceeding 6 ft.:

- Flexible metal conduit
- Liquid-tight flexible metal conduit
- Liquid-tight flexible nonmetallic conduit
- Flexible cords and cables (same conditions as within hoistways)

Within machine rooms, these additional wiring methods are permitted:

- Flexible metal, liquid-tight flexible metal or liquid-tight flexible nonmetallic conduit 3/8 in. or larger, not exceeding 6 ft. in length, are permitted between control panels and machine motors, machine brakes, motor-generator sets, disconnecting means and pumping motors and valves. An exception provides that liquid-tight flexible metal conduit or liquid-tight flexible nonmetallic conduit 3/8 in. or larger is permitted to be installed in lengths in excess of 6 ft.
- Where motor-generators, machine motors or pumping-unit motors and valves are located adjacent to or underneath control equipment and provided with extra-length terminal leads not exceeding 6 ft. in length, such leads are permitted to be extended to connect directly to controller terminal studs without regard to carrying-capacity requirements. Auxilliary gutters are permitted in machine and control rooms between controllers, starters and similar apparatuses.
- Flexible cords and cables that are components of listed equipment and used in circuits operating at 30 V (42 VDC) or less are permitted in lengths not to exceed 6 ft., provided the cords and cables are supported and protected from physical damage and are of a jacketed and flame-retardant type.
- On existing or listed equipment, conductors are permitted to be grouped together and taped or corded without being installed in a raceway. Such cable groups are to

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Arc-Flash Hazards and Electrical Safe Work Practices

by The NEII Safety Committee

This position paper is written to provide guidance to members whose employees are engaged in elevator-industry work that might expose them to arc-flash hazards, and to assist members in complying with applicable OSHA and National Fire Protection Association (NFPA) standards. As recommended in NFPA 70E, the National Elevator Industry, Inc. (NEII) commissioned an arc-flash hazard analysis (in compliance with IEEE Standard 1584-2002 for procedures for calculating the incident energy of the arc flash) by an independent consultant to determine at what level an arc-flash hazard exists to employees who work on energized elevator equipment.

Based on the analysis, the arc-flash boundaries at the elevator/escalator controllers ranged from 3-16 in. from the exposed components, and the incident energy calculated at 18 in. ranged from 0.06 cal/cm^2 to 0.95 cal/cm^2, which indicates that the arc-flash hazard to employees is primarily to the hands and arms. The surest means of avoiding an arc-flash hazard is to lockout and tagout the electrical service to a controller. As stated in Section 7 of the *Elevator Industry Field Employees' Safety Handbook*:

> *"Unless it is not feasible, (i.e.: inspecting; troubleshooting; observing; etc.) employees shall not perform any work on equipment where there is a potential to come in contact with energized mechanical or electrical hazards until all sources of energy have been de-energized, grounded or guarded."*

If the equipment must remain energized to perform work, effective insulation and safe electrical working practices should be observed. Described below are several work practices that may be used to reduce arc-flash hazards when working on energized equipment:

- ♦ Guarding: Where possible, install temporary guarding to protect from inadvertent contact.
- ♦ Fuses: Verify that the correct size, type and capacity are installed.
- ♦ Personal protective equipment (PPE): Use appropriate PPE to protect body parts within the range of 3-16 in. from components that are not otherwise guarded. Examples of PPE that may be appropriate are non-conductive eye protection, clean leather or fire-resistant gloves, and natural-fiber or fire-resistant-rated long-sleeved shirts and pants, or fire-resistant-rated long-sleeved coveralls.
- ♦ Metallic articles: Remove metallic articles such as watches, chains, bracelets, earrings, belt buckles and keychains before troubleshooting. See Section 3 of the *Elevator Industry Field Employees' Safety Handbook*.
- ♦ Instruments: Use category III multimeters and be familiar with their use and limitations. Follow the manufacturer's instructions and precautions. Use Underwriters Laboratories or Canadian Standards Association-labeled scopes tested for 1,000 V.
- ♦ Lockout/tagout: When troubleshooting is complete and further work can be accomplished without the equipment being energized, follow the lockout/tagout procedures in Section 7 of the *Elevator Industry Field Employees' Safety Handbook* before commencing repairs or service work.
- ♦ Special conditions: Troubleshooting in wet, hot or cold conditions calls for extra caution. Hazards created by water, snow or condensation in the work area can cause slips, falls and accidental contact. Don't troubleshoot unless you can keep your shoe/boot soles dry.
- ♦ Mainline disconnect: DO NOT OPEN THE MAINLINE DISCONNECT SWITCH COVER unless employees are authorized, properly trained and appropriate measures are taken commensurate with the higher risk of arc-flash hazards. If power is not being supplied to the elevator controller (e.g., open mainline fuses, etc.), advise the building owner to correct the condition. This is not the elevator company's responsibility.

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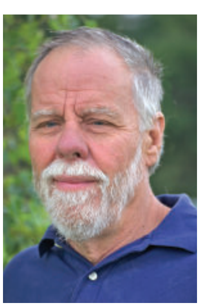
be supported at intervals not over 3 ft. and located so as to be protected from physical damage.
- ♦ Flexible cords and cables in lengths not to exceed 6 ft. of a flame-retardant type and located to be protected from physical damage are permitted in machine rooms without being installed in a raceway. They are to be part of listed equipment, a driving machine or a driving-machine brake.

The following wiring methods are permitted on the counterweight assembly in lengths not to exceed 6 ft.:
- ♦ Flexible metal conduit
- ♦ Liquid-tight flexible metal conduit
- ♦ Liquid-tight flexible nonmetallic conduit
- ♦ Flexible cords and cables, or conductors grouped together and taped or corded, are permitted to be installed without a raceway. They are to be located so as to be protected from physical damage, are to be of a flame-retardant type, and must be part of listed equipment, a driving machine or a driving-machine brake.

Having looked at NEC 2011 mandates for elevator and related equipment installations, we will cover wiring methods, overcurrent protection, grounding and other related NEC provisions in part two of this series, running in the April 2012 issue of ELEVATOR WORLD.

Learning-Reinforcement Questions

Use the below learning-reinforcement questions to study for the Continuing Education Assessment Exam available online at www.elevatorbooks.com or on page 111 of this issue.
- ♦ Name the principal code other than NEC that pertains to elevator design/installation.
- ♦ What is the definition of the machine room?
- ♦ Why are voltage limitations important?
- ♦ In which areas must live parts be enclosed?
- ♦ Why are feeder demand factors permitted for multiple elevators?



David Herres is the author of the recently published book *2011 National Electrical Code Chapter By Chapter*. He holds a New Hampshire Electrician's License and has worked as an electrician, journalist, plumber, carpenter and constructor. Herres has written for such publications as *Electrical Construction and Maintenance, Cabling Business Magazine, Electrical Contracting Products, Electrical Business* and *Engineering News Record* since 2006. He holds a BA in English Literature and Composition from Hobart College of Geneva, New York, but has focused exclusively on electrical work in New Hampshire since 2000.

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- Read the article **"NEC Article 620: Elevators, Part 1"** (page 71) and study the learning-reinforcement questions.
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1. Which areas always allow for full bodily entry?
   a. Control room only.
   b. Control space only.
   c. Control room and machine room.
   d. All of the above.

2. What is the maximum voltage limitation for elevator power circuits?
   a. 150 V.
   b. 250 V.
   c. 350 V.
   d. 600 V.

3. Where are permitted conductors for traveling cables found?
   a. NEC Table 400.4.
   b. OSHA regulations.
   c. A17.1-2007/B44-07.
   d. None of the above.

4. What is the demand factor for 10 or more elevators?
   a. 1.00.
   b. 0.85.
   c. 0.75.
   d. 0.72.

5. Which wiring methods are permitted for elevator hoistways in lengths not exceeding 6 ft.?
   a. Flexible metal conduit.
   b. Liquid-tight flexible metal conduit.
   c. Liquid-tight flexible nonmetallic conduit.
   d. Flexible cords and cables.
   e. All of the above.

6. NEC Article 620 covers:
   a. Elevators.
   b. Dumbwaiters.
   c. Escalators.
   d. All of the above, plus moving walks, platform lifts and stairway chairlifts.

7. A17.1-2007/B44-07 does not cover:
   a. Dumbwaiters.
   b. Moving walks.
   c. Platform lifts.
   d. None of the above.

8. Heating and air-conditioning equipment located on cars must not exceed:
   a. 600 V.
   b. 350 V.
   c. 250 V.
   d. 150 V.

9. Clear working space around electrical equipment that may need servicing must be the width of the equipment or at least:
   a. 60 in. wide.
   b. 48 in. wide.
   c. 30 in. wide.
   d. 24 in. wide.

10. Working space around electrical equipment that may need to be serviced must be the height of the equipment or at least:
    a. 6 ft. high.
    b. 6-1/2 ft. high.
    c. 7 ft. high.
    d. 8 ft. high.

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