Maintenance on New Equipment Designs: Ascending Car Overspeed Protection and Unintended Car Movement Protection, Controllers and Listing and Labeling

Requirements from the Code impacting these three areas

by John Koshak

Ascending-Car Overspeed Protection and Unintended Car Movement Protection

Since 2000, the ASME A 17.1/CSA B44 Safety Code for Elevators and Escalators has required two new forms of protection, specifically because of elevator component failures. Several components have failed such as bolts, gears, shafts, control systems and brakes, causing the empty car to ascend, accelerating unchecked until hitting the overhead. This condition, though rare, has had catastrophic results, both to the system itself and passengers. In order to prevent these types of accidents, the Ascending Car Overspeed Protection (ACOP) requirement mandates the use of an emergency brake to drop and bring the car to a stop:

> *"The requirements provide protection against ascending car overspeed and/or collision of the elevator with the building overhead by requiring detection of ascending overspeed of the car and operation of an emergency brake.*
>
> *To ensure the safe functioning of the detection means, redundancy is required so that no single specified fault will lead to an unsafe condition. Checking of this redundancy is also required. Once the detection means is activated, a manual reset of the detection means is required." (Donoghue, pg 141)*[1]

The Code now requires protection against several types of failures collectively called Unintended Car Movement Protection (UCMP), due to various electrical or electronic control systems failures. This system is required to prevent a car from traveling more than 1,220 mm (48 in.) from the landing in either direction, with the car and hoistway doors open by requiring detection of the unintended motion of the car and operation of an emergency brake. It is critical to understand that when the emergency brake is operated due to such a failure condition, a manual reset is required. Otherwise, the drive system will continue to attempt to move the car up to the torque limits of the system. In some cases, this might even cause the torque to drive

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Learning Objectives

After reading this article, you should have learned:

- The maintenance, inspection and testing, and repair and replacement requirements for ACOP and UCMP
- The maintenance, inspection and testing, and repair and replacement requirements for controllers
- The maintenance, inspection and testing, and repair and replacement requirements for listing and labeling
- The most novel of all the changes brought about by machine-room-less (MRL) systems
- What is required by the Maintenance Control Program (MCP)

Value: 1 contact hour (0.1 CEU)

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through the brake itself, such as with a motor generator, if the suicide circuit is not functioning correctly.

> *"To ensure the safe functioning of the detection means, redundancy is required so that no single specified fault will lead to an unsafe condition. Checking of this redundancy is also required. Once the detection means is activated, a manual reset of the detection means is required. The reason for specifying that power be removed from the drive motor of the motor-generator set is because of the concern for protection against the failure of the 'suicide circuit.' An important consideration in formulating this requirement is the fact that it will prevent regeneration back to the AC line, and in so doing, may extend the braking distance." (Donoghue, pg 141)*[1]

Maintenance

These systems use an Emergency Brake to protect against failures and rely on two systems: the control system that activates the emergency brake and the mechanical system that actuates to bring the car to a stop. Because of the importance of the activation circuits, there are requirements to ensure that the monitoring and control circuits cannot become ineffective. There is little to maintain, and in most cases, there is nothing to maintain except cleanliness of the printed circuit board (PCB). The emergency brake itself may require maintenance to ensure that the pads are not worn, the brake operates freely and debris or rust has not impacted its correct operation.

The emergency brake will likely be attached to the driving machine and, therefore, located in the hoistway. Some systems use a safety device that grabs the rails to develop this braking force. Maintenance of MRL emergency brakes is done from the car top, in most cases. Using these procedures to safely be on the top of the car is vital: Visually inspect the emergency brake for any signs of debris and verify the thickness of the brake pads. The procedures are required when the system is unique, which is likely in all cases.

Inspection and Test

Requirements exist for the periodic demonstration of the performance of these safety systems. With MRL units, testing of both of these protection systems is different from legacy systems, because of the lack of visual confirmation afforded when the machine is in a machine room, in sight of the controller demonstrating the systems. Requirement 2.7.6.4.1 is the mitigation for this new location.

The devices in the Test and Inspection Panels shall remain operable during a failure of the normal building power supply. The power source shall be capable of providing for the operation of the display devices or the equivalent of at least 4 h. Where batteries are used, a monitoring system shall be provided. In the event that, during normal operation of the car, the monitoring indicates insufficient power to operate the display devices or the equivalent, the car shall not be permitted to restart after a normal stop at a landing.

The testing of the ACOP and UCMP ordinarily requires direct observation of the movement of the car, and since the MRL drive machine is in the hoistway and typically not visible, the requirement is to provide this data from the area where the test is performed. The new location does not present any new hazards to elevator personnel. The moving equipment is secure in the hoistway just as it is with legacy equipment. In fact, without the driving machine and elevator under the machine-room floor, potentially hitting the underside of the machine-room floor, it is arguably safer to perform this test from an adjacent location where most inspection and test panels are located. This new location allows the running of the elevator and, while observing the display device, tripping of the appropriate circuits to directly determine compliance.

Adjustment, Repair and Replacement

ACOP and UCMP systems are mechanical and electronic in nature and, therefore, can likely require mechanical adjustment. Any alteration to the existing systems (or their addition to older systems) must be added to the code data plate. This might be a change of a brake design or use of a different brake-pad material. The importance of this safety function mandates the control of the original approved design by requiring any alteration to be recorded.

Since these systems are electronically activated and reliant on software, software revision control is now required with addition of Unique Software Identified (USI) requirements. In fact, many control systems in critical operating circuits are software reliant. These new requirements ensure that alterations to the software do not change the ability of the safety circuits to function as intended. One scheme is to separate the critical software into a separate sub-system with a redundant microprocessor or other hardware device that allows operational control software to be changed without the risk of interfering with the safety software. Any alteration of the safety software would be identified by a change in the checksum or another recognized method of determining software differences from the original safety software used at the acceptance inspection and subsequent periodic inspections. There are many solutions; however, the alteration of this software must be verified by a complete testing of the safety functions. The new USI requirements are: includes all executable software, not parameter software, that essentially can permit the car to move or move beyond the terminals, emergency communications, Firefighters' Emergency Operation and many other critical sub-systems, and functions. The elevator system is required to have a means to view the USI including electronic viewing, labeling the EEPROM (Electrically Erasable Programmable Read-Only Memory) or labeling or tags on the controller enclosure. The information must be available.

Repair and replacement are likely to occur in the life cycle of the elevator, as they typically have their signals generated from discrete encoders. Therefore, as applicable components defined in Section 8.6 and based on their product uniqueness, these procedures must be in the MCP.

Conclusion

The location for performing these procedures is new when comparing legacy equipment to MRL units. Procedures for testing and inspecting, adjustment, repair and replacement must be included in the MCP and available for elevator personnel to maintain the conveyance in compliance with Section 8.6.

Materials Required by the MCP

- ♦ Any product-specific procedures or methods for tests, inspections, maintenance, replacement and repairs
- ♦ Schedule of maintenance requirements
- ♦ Records of testing
- ♦ Records of replacements
- ♦ Records of alterations

Controllers

The placement of the elevator controller in the hoistway is perhaps the most novel of all the changes brought about by MRL systems. However, my experience is that there is a fundamental misunderstanding of what "controller" means in the industry. Since 1996, controllers have been split into three distinct units.

The Code has further defined what a controller is, and it has significant impact on alteration requirements. Alterations are commonly known as modernizations and require a permit from the AHJ. The controller for most elevator personnel is one thing, but it is actually divided into three systems. The Motion Controller, the Motor Controller and the Operational Controller. The Motor Controller is where the high power is connected to the driving machine, a soft-start, a contactor or a solid state motor drive. The Motion Controller is the subsystem that tells the Motor Controller it is OK to run the elevator. It is where the safety circuit is located electrically. The Operational Controller is the subsystem that tells the elevator where to go in response to a user demand or a zoning demand.

With legacy equipment, the "controller" in the machine room usually housed the three units (subsystems) in one enclosure. With MRLs, there is a tendency to split the controller subsystems and locate each unit where it is appropriate for the work that will be done on it and to be in proximity to a component such as the driving machine. Where the components were located and what accessibility was required from the hoistway, hallway or room and what didn't necessarily require access from outside the hoistway became the basis for the design of the new locations.

It is easy to think that one controller with three subsystems inside one enclosure shouldn't be changed or split, but this does not fully capture the overall picture. In a machine room, size is not as critical as with MRL units; when space becomes a design criterion, each component should be considered relative to its function in the system and located accordingly.

The motor controller is the high-voltage, high-current device that provides the electromotive force to turn the driving machine. In legacy equipment, this is a large contactor with contacts that potentially wear off or motor-generator sets with brushes and their field-controlled circuitry (both requiring constant maintenance). In modern elevators, this is more often a solid-state device — a motor drive. The high current is switched through large transistors or silicon-controlled rectifiers. There are no moving parts; nothing wears out (in the same sense as a contact in a contactor).

Figure 1: Typical controller; image courtesy of Richard Baxter

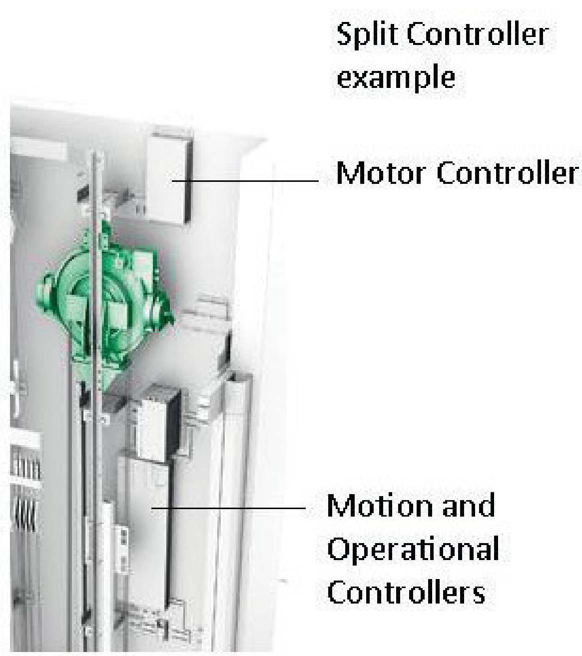

Figure 2: Typical split controller; image courtesy of KONE

The motion controller is typically the unit that provides output drive signals to the motor controller, which outputs feedback back to the motion controller in order to control the driving-machine current and voltage (and, therefore, its position). The motion controller takes input from the operational controller, which is usually the unit that takes input from passenger demands, outputs information back to the passenger that the call is registered and provides position indication. Thinking in terms of hazard, the motion and operational controllers use a relatively low voltage, the output of which is translated by the motor controller to provide the high power to drive the elevator to a desired destination within the acceleration, jerk and accuracy constraints allowed by the

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code and the designer. Since the operational and motion controllers can be made safe by virtue of their inherently low power, it is possible to locate these behind doors that, if open, do not present an electrocution danger. The motor controller must be contained and have working clearances around it to provide safety to elevator personnel and the general public, due to its high power.

With the use of reliable controls, redundancy, checking and other methods of the electronic controls protection, any failure of the systems will result in the immediate removal of power from the drive motor and brakes. The present code required designs that can be problematic to the point of causing nuisance shutdowns, not due to dangerous conditions; this is always a concern to designers. There is also a hazard created when shutdowns are excessive for any reason.

Also, with the use of solid-state drives, it is favorable to have them as close to the drive machine as possible to reduce radio-frequency energy emitted from the wires from going to the motor. This is the primary reason to split the controller units and locate the motor controller in the hoistway near the drive machine, since the drive-machine motor is in the hoistway. Depending on the design, the motion controller may be located in the hoistway, as well, leaving the operational controller to be accessed from outside the hoistway.

Unlike working from a machine room that provides access to all controller circuitry and the driving machine and brake, with an MRL the Code mitigates the loss of total access to a list of items by requiring many components, circuits and functions to be accessible from outside the hoistway. This is critical for elevator personnel to fully understand. The Inspection and Test panel has been mentioned before: What is required to be in it is critical for safe operation by elevator personnel.

These are important provisions that must be understood by all elevator personnel working on MRLs. The availability of these circuits for troubleshooting and maintenance is one of the fundamental reasons MRLs can be designed safely. There are many tasks that must be done from the controller, many items that may need a technician to have access to that were apparently taken away when the machine room disappeared. The Code provided the critical elements to be accessible in the same way and with required visual representation as was provided in a machine room.

Maintenance

Since there are three units in a control system, let's split the maintenance into three components as well. This will illustrate the thinking behind many designs.

Motor Controller: Modern designs of solid state drives have little to be maintained. There are no moving parts, save a cooling fan, in many designs. There are no parts that through normal operation will wear out or require maintenance. It is another case of it works or it doesn't. Most drives have a serial communication capability that will display status parameters to a tool plugged into the Operational Controller for determining if any of the drive components are having issues outside the hoistway. Keeping dirt and debris out of the controller cabinet and off the PCBs and ensuring that it doesn't overheat because of a fan failure is all the maintenance that can be done. Think of a transistor radio — it either works, or it doesn't — you don't maintain any component of a radio, simply blow off any accumulated debris that may electrostatically collect. Some devices may degrade over time; however, the design requirements for critical operating circuits require that the failure of a device shall not render the system unsafe.

Motion Controller: This unit may be inside or outside the hoistway and is mostly electronic, though there may be some relays that control certain circuits. Relays are an electro-mechanical device and in time, some will likely fail. Generally, these relays are monitored in order to ensure proper operation as required by Code. Given enough time and experience, these relays and their contacts will have a history of their robustness, and in some cases, they should be replaced prior to their failure in order to ensure the elevator remains in service. Maintenance may be to pull them out and test them or simply visually inspect them for evidence of excessive arcing; it will depend on the design and company procedure. Most of the motion controller will be examined through a serial communication link or internal communication system to provide information on the health of the system by plugging a display device into the operational controller outside the hoistway. Removal of debris is very important for any electrical equipment, and it's the same here.

Operational Controller: This unit will most likely be the component that is fully accessible from outside the hoistway; it is typically the place where all testing is performed from and witnessed during an inspection. In addition to Code-required testing, this is likely where the hall and car door bypass switches are located, a Code required circuit that allows the bypassing of the interlocks and door contacts in order to perform maintenance in hoistway without having to use a jumper.

It is critical for elevator personnel to be aware of the new possibility of unexpected car movement as a result of working on the motor or motion controller in the hoistway if the designs have these split and mounted in the hoistway. Use the blocking means provided whenever the controller cover is open. The working clearances required by NFPA 70 (National Electric Code) are based on the location of the blocked car top. Always use the blocking means. Always use the blocking means. ALWAYS USE THE BLOCKING MEANS. It needs to be emphasized to use the blocking means whenever working on equipment that can cause unexpected car movement. This includes maintenance such as cleaning out the controllers mounted in the hoistway or replacing relays or other components or devices in the controllers.

The visual to remember this is the cartoon where the dope is sitting on a branch that he wants to trim, and he cuts the branch behind him and falls. Do not work on anything that can potentially move the car unless the blocking means is in the locked position.

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Inspection and Test

Since the operational controller is the unit most likely accessible from outside the hoistway, all testing and inspection will be performed from there. With the almost complete electronic nature of modern controllers, the controller testing is done with software test functions and the use of a tool, either a dedicated tool or a laptop. Because of the nature of the software, it is impossible to detail every test procedure in this book; each OEM will provide these to the inspection authority. As mentioned previously, these inspection guides are available through the OEM or available from NAESA International.

The Code now requires recording the software version for reference by elevator personnel to verify that when new software is added, all safety functions still work correctly. This must be viewable at the controller and available without any password protection. It can be a tag on the controller where the software is recorded and compared to an electronic display on the controller without special tools or passwords. Some means must be able to demonstrate the software has not been changed and tested for proper function of many safety functions. It can be the tag on an EEPROM, as well, provided the tag is permanent and has not fallen off over the years.

All other tests in the hoistway, pit and car top will remain the same. The machine-room tests will be split to some at the panel and some in the hoistway from the top of the car. These present no new hazards. The testing and inspection from the top of the car always existed.

Adjustment, Repair and Replacement

The controller is one of the items on the alterations list, but conditionally. Knowing what changes can be made without having to upgrade many other components requires reading and a thorough understanding of Section 8.7.

Some adjustments, repairs and all replacements will require compliance to the listing/labeling requirements and an update of the code data plate. The location of controllers presents new hazards when work is performed in the hoistway. Procedures for top-of-car blocking means and lockout/tagout are very critical when working from the top of the car on electrical equipment, especially the motor controller (if located in the hoistway).

Conclusion

There are new hazards created by the MRL when any unit of the controller is located in the hoistway and not in a machine room. This can potentially lead to car movement in new ways. However, the protections required to be provided still require the technician to use them to be protected. Remember that throwing the car top inspection transfer switch does not alone prevent the car from moving. If the technician opens a controller and makes an error while troubleshooting, the car can potentially move.

Materials Required by the MCP

- Any product-specific procedures or methods for tests, inspections, maintenance, replacement and repairs
- Schedule of maintenance requirements
- Records of testing
- Records of replacements
- Records of alterations

Listing and Labeling

E/E/PES Devices and Listed/Certified Devices

Legacy equipment used for more than a century has a relatively known measure of reliability because of design improvements due to innovation and Code design requirements. Today, the Code requires many components to be independently tested by third-party investigators and have a certification granted upon successful testing of the component to Code design requirements. Interlocks, entrances, electronic devices and final limit switches are a few examples.

These devices are labeled and listed by an accredited certifying organization: Underwriters Laboratories, Intertek, Canadian Standards Association, etc. As technology continues to advance, the ability to utilize Electrical, Electronic and Programmable Electronic Systems (E/E/PES) in safety-related functions is made possible because of the inherent safety and reliability these devices are designed to have.

While nothing that is man-made can last forever, there are designs that can notice their own failure and take measures to prevent a resultant unsafe condition. These methods are defined in Standards that define levels of probability of failure inherently designed into E/E/PES devices. Since 2007, A17.1 has allowed the use of E/E/PES devices in safety-related functions, typically as alterations to Electro-Protective Devices (EPDs). In legacy equipment, this reliability was typically designed and prescribed with a mechanical testing for a number of cycles.

More specifically, to design an interlock, the design must endure 960,000 cycles of opening and closing with current going through the contact and other tests. These tests prove the design, and the assumption is that the design will not fail and cause an unsafe condition. While the test of time has shown this to be a good engineering practice, it is left with the fact that there may be manufacturing defects that creep into the marketplace, and it may fail without any safeguard of the consequences. With E/E/PES devices, even such consequences are protected against.

These devices are also investigated by third-party certification organizations and tested for compliance to standards to ensure their correct functioning. They are then labeled and listed with a Safety Integrity Level (SIL) that requires all aspects of the device to remain unaltered. In fact, trying to alter them usually results in their shutting down safely. This includes inadvertent changes made by an unfamiliar technician or by a malicious hacker. The software is particular to the component; many sub-components are monitored and the entire device relies on its own standalone integrity. After passing the rigorous testing by a third party, it becomes a controlled device requiring special replacement, adjustment and repair procedures.

E/E/PES devices are very different from standard PLCs, which have been used for many years in the industry, though they may look similar. Because they have inherent safety features, they cannot be tampered with and (most importantly), if any component goes bad, it will assume a defined safe state; hence the Code has allowed them to be used.

Continued

This is not an MRL issue; however, it is new technology, and technicians will likely come across it. E/E/PES devices must have their documentation included in the MCP. Their label will display their SIL level. They will replace many conventional devices used today as time goes by in order to reduce failures of mechanical components, increase reliability and up time of the elevator system and allow novel elevator designs.

Adjustment, Repair and Replacement

Each device will have specific adjustment, repair and replacement requirements provided in the documentation.

Conclusion

The next wave of technological improvements will bring novel designs. The reliability may not be evident by looking at these devices, but rest assured they do have intrinsic safety.

John W. Koshak is the head and founder of Elevator Safety Solutions, LLC. In 2016, he founded eMCP, LLC, to provide code-compliant Maintenance Control Programs (MCP) for owners and companies. He was formerly in research at thyssenkrupp Research, Innovation and Design, and director of Codes and Standards. Koshak got his start in the industry in 1980 at Westinghouse Elevator Co. and has worked for Dover Elevator, Amtech Elevator and Adams Elevator Equipment Co., where he was vice president of Technical Support. He was a National Elevator Industry Educational Program instructor from 1982 to 1991, designed the LifeJacket hydraulic elevator safety and holds several U.S. and foreign patents. Koshak has authored two books, including a novel in 2006 (*The Pool Manager*) and a technical book on the MCP in 2010 (*Maintenance on New Equipment Designs*). He has authored three Certified Elevator Technician (CET®) courses: Course 7, Unit 13, Construction Wiring and Equipment; Course 8, Unit 14, Hydraulic Theory and Installation; and Course 6, Traction, Theory, Maintenance, Testing and Safety. He has authored more than 30 articles, including seven continuing-education (CE) articles for ELEVATOR WORLD. He is approved as an instructor in several states, providing code education for CE for mechanic licensing. He is currently a member of the ASME A17 Standards Committee, as well as a member of several ASME, CSA, UL and ANSI committees. He is a NAESA International-certified elevator inspector, C2346 and instructor. He is currently a member of the Board of Directors for EW and is part of its Technical Advisory Group. He was formerly president of the International Association of Elevator Consultants, a member of the NAEC Education Committee and the NAEC Board of Certification for the CET education program, chairman of the NAEC Codes and Standards Committee and chairman of the Elevator Escalator Safety Foundation.

Their applications will have been reviewed by independent third parties. They will replace conventional components such as governors, interlocks, limit switches and may even eliminate some components such as buffers and safeties. This will truly be the revolution in the elevator industry.

With each of these novel improvements, the documentation will be required to be available to elevator personnel regardless of company. The owners must take control of the documentation of these conveyances to ensure the safe operation throughout the life cycle of the unit.

Materials Required by the MCP

- Any product-specific procedures or methods for tests, inspections, maintenance, replacement and repairs
- Schedule of maintenance requirements
- Records of testing
- Records of replacements
- Records of alterations
- Record of oil loss
- Firefighters' Emergency Operation Testing
- Call back records
- Maintenance Procedures

Reference

[1] Donoghue, Edward (2007). ASME.1/CSA B44 Handbook. New York City, NY = ASME. Pg 141

Learning-Reinforcement Questions

Use the below learning-reinforcement questions to study for the Continuing Education Assessment Exam available online at elevatorbooks.com or on p. 107 of this issue.

- What are the maintenance, inspection and testing, and repair and replacement requirements for ACOP and UCMP?
- What are the maintenance, inspection and testing, and repair and replacement requirements for controllers?
- What are the maintenance, inspection and testing, and repair and replacement requirements for listing and labeling?
- What is the most novel of all the changes brought about by MRL systems?
- What is required by the Maintenance Control Program (MCP)?

Accounting of Time For Article:

- Learning Objectives:
  30 Minutes (Page 69-76)
- Conclusion – Materials Required by the MCP
  30 Minutes (Page 76)

ELEVATOR WORLD Continuing Education Assessment Examination Questions

Read the article **"Maintenance on New Equipment Designs: Ascending Car Overspeed Protection and Unintended Car Movement Protection, Controllers and Listing and Labeling"** (EW, June 2025, p. 69) and study the learning-reinforcement questions at the end of the article.

- To receive **one hour (0.1 CEU)** of continuing-education credit, answer the assessment examination questions found below online at elevatorbooks.com or fill out the ELEVATOR WORLD Continuing Education reporting form found overleaf and submit by mail with payment.
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1. The maximum distance that the elevator can move with the hoistway doors open during UCMP is:
   a. 150 mm (6 in.).
   b. 300 mm (12 in.).
   c. 1,220 mm (48 in.).
   d. 3,000 mm (60 in.).

2. With modern elevator control systems, electronics and software are primary components and software should be:
   a. Monitored for changes.
   b. Available online.
   c. Used in a flash drive.
   d. Failsafe.

3. ACOP and UCMP use electronics primarily to sense the condition of the elevator and are required to:
   a. Have software checked prior to the next start.
   b. Be on the car.
   c. Be available from the internet.
   d. Be in the building office.

4. The key feature(s) of an MRL is/are:
   a. The splitting of the controller into separate sections.
   b. The use of novel suspension systems.
   c. Having a test and inspection panel.
   d. All the above.

5. An elevator controller is comprised of how many subsystems?
   a. One.
   b. Two.
   c. Three.
   d. Four.

6. The motor controller is typically mounted close to the motor:
   a. Because wiring is less expensive.
   b. To reduce radio frequency emissions to a minimum.
   c. So that it is conveniently close to the motor to work on.
   d. Because it doesn't matter.

7. The inspection and test panel is required to house:
   a. Several safety circuits and the hoistway and car door bypass switches.
   b. The I/O terminal blocks.
   c. The barricade to prevent public access.
   d. The motor controller.

8. The motion controller:
   a. Is required to be in the hallway.
   b. Is required to be in the hoistway.
   c. May be in the hoistway or hallway.
   d. Is near the bottom floor pushbutton.

9. New E/E/PES technologies must:
   a. Never be used.
   b. Be listed and labeled as referenced by the Code.
   c. Be used first in Europe or Asia.
   d. Be allowed unconditionally.

10. Certain devices can use E/E/PES replacements. They are:
    a. Structural components of the machine beams.
    b. Hoistway door restraining devices.
    c. Electrical protective devices.
    d. Not mentioned in the Code.

ELEVATOR WORLD Continuing Education Reporting Form

Article title: **"Maintenance on New Equipment Designs: Ascending Car Overspeed Protection and Unintended Car Movement Protection, Controllers and Listing and Labeling"** (EW, June 2025, p. 69)

Continuing-education credit: This article will earn you one contact hour (0.1 CEU) of elevator-industry continuing-education credit.

Directions: Select one answer for each question in the exam. Completely circle the appropriate letter. A minimum score of 80% is required to earn credit.

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This article is rated for one contact hour of continuing-education credit. Certification regulations require that we verify actual study time with all program participants. Please answer the below question.

How many hours did you spend reading the article and studying the learning-reinforcement questions?

hours: ____________ minutes: ____________

Circle correct answer.

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3.	a	b			8.	a	b	c	d
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