



## WHAT OPERATIONS NEED TO KNOW ABOUT SERVICING HIGH-VOLTAGE EQUIPMENT

**H**eavy-duty forklifts and even bigger machines including port equipment like empty or laden container handlers, ReachStackers and terminal tractors are increasingly powered by electric sources like batteries, rather than internal combustion engines (ICE). To achieve the charging speed and power delivery required by applications with demanding duty cycles and heavy loads, this high-capacity electric material handling equipment relies on high-voltage battery systems.

To be clear, not all electric materials handling equipment uses high-voltage batteries. For example, a 4,000-pound, or 2,000-kilogram, capacity counterbalanced forklift with an integrated lithium-ion battery might use a dual voltage battery that can operate at 48 or 96 volts (V).

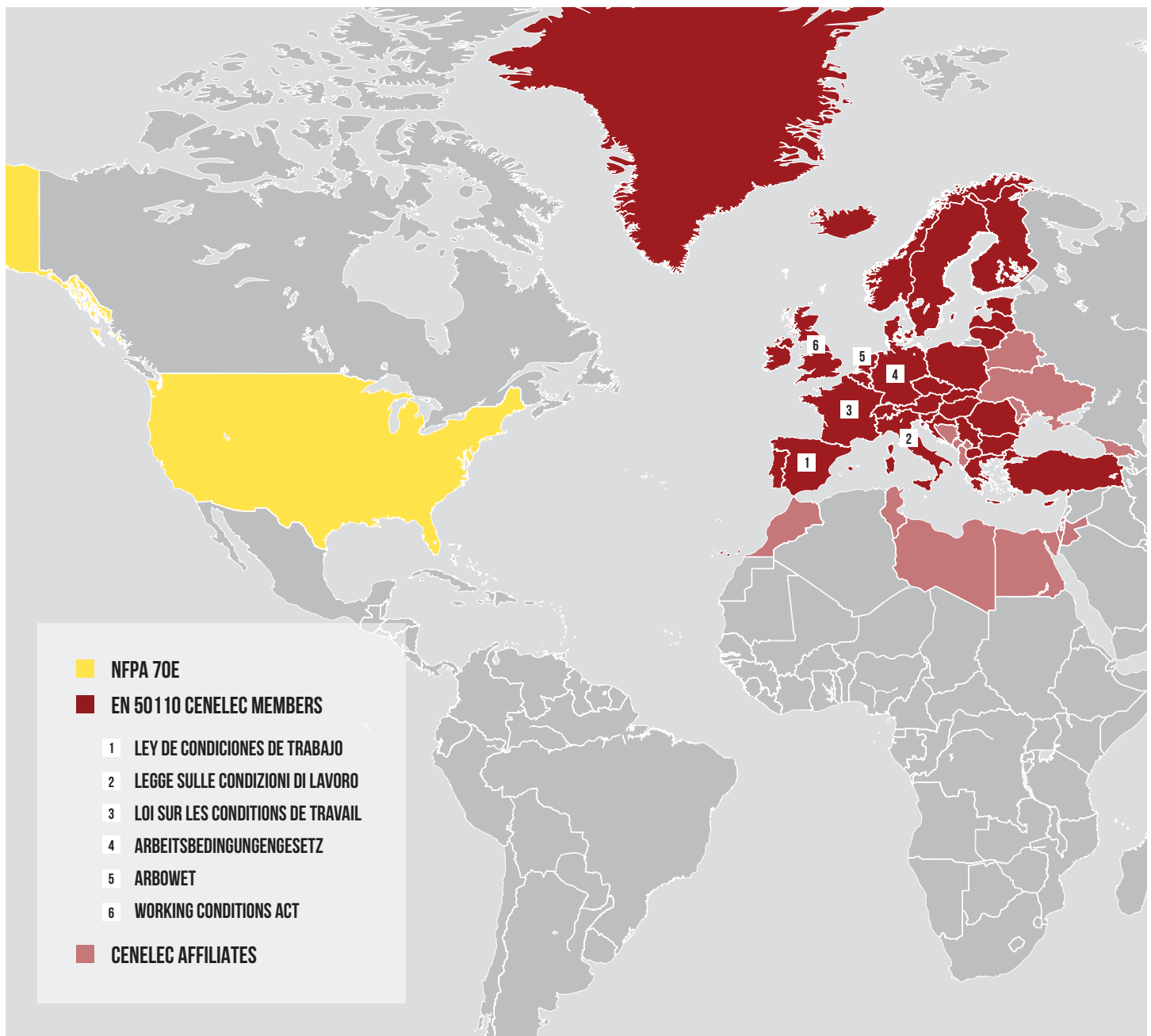
However, for equipment that does use high-voltage battery systems, there are important safety considerations for equipment maintenance and service that operations must understand and comply with to prevent electrical danger or injury.



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### // ELECTRICAL SAFETY RESPONSIBILITIES

Different parts of the world have different governing bodies and regulations concerning electrical safety. In the United States, the Occupational Safety and Health Administration (OSHA) has requirements based on the National Fire Protection Association (NFPA) 70E, Standard for Electrical Safety in the Workplace. For member and affiliate countries in Europe, the Middle East and Africa (EMEA), the European Committee for Electrotechnical Standardization (CENELEC) defines the EN 50110, but individual countries can also have their own laws that operations in those locations must obey, so it is important to investigate the local legislation in the area where you operate.





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A common theme from both the NFPA 70E and EN 50110 is that there is a shared responsibility for electrical safety. The owner of the premises where equipment is being maintained or serviced, their equipment dealer and the manufacturer all need to work together with a shared interest in the safety of work being performed.

NFPA 70E	
Owner of premises (Host employer) + Equipment dealer (Contract employee)	Equipment manufacturer
<p><b>Site-specific or company policies must address:</b></p> <ul style="list-style-type: none"> <li>• Electrically safe work condition policy</li> <li>• Lockout/tagout policy</li> <li>• Safe work practices</li> <li>• Risk assessment</li> <li>• Training</li> <li>• Personal protective equipment (PPE) and tools</li> <li>• Audit policies</li> <li>• Investigation plans</li> </ul>	<ul style="list-style-type: none"> <li>• Provide product training and product certification for dealers</li> </ul>

EN 50110		
Owner of premises	Equipment dealer	Equipment manufacturer
<ul style="list-style-type: none"> <li>• Provide a safe space for maintenance and service activities</li> <li>• Minimize distractions and noise to support focus</li> <li>• Consider towing capabilities in case truck must be removed quickly</li> </ul>	<ul style="list-style-type: none"> <li>• Properly train technicians and personnel in electrical safety</li> <li>• Have an assignment policy with appropriate practices in place</li> <li>• Provide a clear, written work order</li> <li>• Equip employees with PPE</li> </ul>	<ul style="list-style-type: none"> <li>• Provide product training and product certification for dealers</li> </ul>

### *ARC FLASH AND OTHER ELECTRICAL DANGER IS A RISK OPERATIONS CANNOT AFFORD*

In certain parts of the world, the fine can range from €50,000 - €200,000 for an incident or neglect such as failure to have proper certification, work order, assignment policy and PPE.

In the U.S., OSHA penalty amounts vary for different types of violations but can range from about \$16,000 to more than \$160,000.





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## // TRAINING AND CERTIFICATION REQUIREMENTS

While it's very common for operations with materials handling equipment like forklifts and container handlers to service their own equipment, maintenance or repair work on high-voltage circuits, often identified by orange cables, requires individuals who are certified to work with these kinds of systems. While NFPA 70E only specifies one level of certification and EN 50110 identifies three, both regulations:

- Identify the technical knowledge required by individuals in order to work with high-voltage equipment
- Require individuals to be recertified every three years\*

\*NFPA also requires annual field work audits



NFPA 70E (U.S.)	EN 50110 (EMEA)
<p><b>Qualified person</b></p> <p>One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify the hazards and reduce the associated risk. A qualified person must be familiar with and demonstrate an ability to use the following:</p> <ul style="list-style-type: none"> <li>• Special precautionary techniques</li> <li>• Electrical policies and procedures</li> <li>• PPE</li> <li>• Insulation and shielding materials</li> <li>• Insulated tools and testing equipment</li> </ul> <p>Training must also cover:</p> <ul style="list-style-type: none"> <li>• Lockout/tagout procedure training</li> <li>• Emergency response training, including contact release, first aid and resuscitation</li> </ul>	<p><b>Electrical instructed person (EIP, also known as VOP/EUP)</b></p> <p>One who is allowed to pull the master service disconnect (MSD) but not to measure 0-volt in the system. They assist the high-voltage technician (HVT) in working on high-voltage components and are able to assess the risks of the task at hand and deny work if in doubt about the situation.</p> <hr/> <p><b>High-voltage technician (HVT, also known as VP/EFK)</b></p> <p>One who is allowed to pull the MSD and allowed to measure 0-volt in the system. They are able to work on high-voltage equipment independently or with the help of an EIP. They must understand when procedures are not clear and are able to consult with the high-voltage work supervisor (HVWS).</p> <hr/> <p><b>High-voltage work supervisor (HVWS, also known as WV/VEFK)</b></p> <p>One who is responsible for defining procedures and seeing to it that procedures are followed.</p>



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### Product training

In addition to electrical certification, individuals must also have training and certification specific to the materials handling equipment they will be working directly with. This is because electrical training can equip an individual on something like how to pull a master service disconnect (MSD), one of the first steps to disengage the high-voltage system. But additional knowledge about the specific equipment is also needed, such as the location of systems or how they work together on that particular model. The frequency with which individuals must be recertified in product-specific training may vary based on the equipment manufacturer and how frequently their equipment designs are updated.

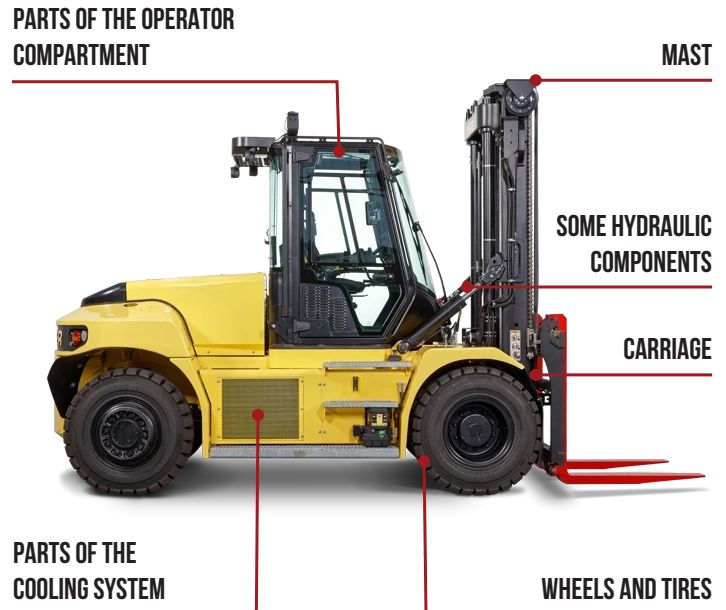
### What does this mean for operations?

At the most foundational level, businesses need to be aware of these requirements so that they only allow individuals with proper certification to participate in maintenance or repair work that requires specialized training. To that end, businesses should confirm that their authorized dealer's technicians are current on the certifications required in that location and for that equipment.

Businesses can also consider having their in-house technicians certified, when feasible, to reduce potential wait times for work on mission-critical equipment. Two technicians are required when disconnecting and reconnecting high-voltage systems: one technician working on the truck and another in a support role to immediately intervene if necessary. If a business has their own certified person available, that individual can take the assist role if a single outside technician is available. For operations that are extremely sensitive to equipment downtime, this certification may be particularly valuable. Some facilities have industrial alternating current systems that are also subject to NFPA 70E requirements and for which they have a facility electrical safety program.

Such an operation may be able to include truck technician certification in the facility's existing electrical safety program. Dealers themselves are not qualified to certify candidates, but some may be able to help businesses with instructions on the certification process.

While it is essential that only certified individuals are engaged in work that requires such certification, not all work on this equipment, like changing windshield wipers or light bulbs, requires certification. Maintenance or repairs on systems that are not powered by high-voltage circuits may not require technicians who are certified in electrical safety. This could include components such as:





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Operations and their technicians should carefully review the service manual for the particular forklift or container handler they plan to conduct service or maintenance on to understand whether certified individuals are required for specific work.

In the U.S., for work that does require a qualified individual to deenergize the system, a different technician, including mechanics who are non-qualified individuals, can complete the service tasks after the qualified individual has measured 0-volts. Similarly, in EMEA, once a high-voltage technician (HVT) has measured 0-volts, a mechanic who is only an electrical instructed person (EIP) could perform the service tasks. The HVT would then evaluate the work before reconnecting the high-voltage system.



### // SAFETY PRACTICES AND SYSTEMS

In addition to training necessary individuals or working with dealers who can provide trained technicians, there are other important steps and systems businesses with high-voltage equipment should understand. The following list of considerations is not exhaustive but highlights several priorities for electrical safety.

#### **1. Establish your chain of command and procedures.**

Under EN 50110, this is considered an assignment policy. Operations must communicate high-voltage safety requirements to everyone in the organization, not just those doing the work. It is important for all to understand the meaning of signage such as high-voltage or danger symbols, cones or pylons and barricade tape that may be used to indicate a restricted work area they should not enter because of risk of severe injury.

#### **2. Designate an area for high-voltage work and mark it clearly.**

The space must be clearly marked every time high-voltage components could be exposed. The area should also have a short escape route to the outdoors in case of a thermal runaway event.

#### **3. Prepare a risk assessment form for the service mechanic.**

Among other items, the form may include procedures and checkpoints concerning the support technician, the site and the truck. Businesses that are not performing the electrical work with their own certified individuals must inform any contract employees, such as dealer technicians, of any changes to the truck that could affect the electrical system. The business, also known as a host employer, should also report any violations of NFPA70E or the relevant local electrical safety considerations to the contract employer.



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### USED FOR MAINTENANCE AND REPAIRS

#### Master Service Disconnect (MSD)

Also referred to as a manual service disconnect, the truck MSD breaks the series connections within the battery, making the contactor connections to the motor inactive. Using the MSD is typically the first step for shutting down and securing a high-voltage circuit in the truck. Rubber gloves and other prescribed PPE must be worn when pulling the MSD, which is usually located behind an unlocked door on the truck and marked with a triangle decal with a flash or lightning bolt symbol.

#### High-Voltage Interlock Loop (HVIL)

This continuous low-voltage wire runs through all of the high-voltage connections in the system to monitor the integrity of the circuit and the security of all high-voltage covers. If the loop is broken because the MSD has been pulled or a cover is open, this system disables the contactors so they cannot engage and the high-voltage system is not activated.

### RUNNING CONTINUOUSLY FROM TRUCK KEY-ON

#### Ground Fault Detection (GFD)

High-voltage wire has a metal shield that is connected to the truck. When there is an abrasion on the wire, the ground fault detection senses it and disconnects the truck, triggering a fault code so that operation of the truck is halted until the issue has been resolved.

#### Power Enable Loop (PEL)

This software monitors the temperature and voltage in a battery module. When a battery module goes out of its rated temperature or voltage range, the power enable loop opens and that battery is disabled to allow it to return to an appropriate temperature or to allow the voltage imbalance to be corrected.



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### // GIVEN THE RISKS AND EXTRA CARE, WHY GO ELECTRIC?

Pressure is mounting to move toward a more sustainable future. The U.S. and European Union have pledged to significantly reduce greenhouse gas (GHG) emissions and accelerate the transition from fossil fuels to renewable energy sources, and regulatory requirements are growing. The California Air Resources Board (CARB) approved regulations for the state that require a transition to zero-emission forklifts by 2038 and has drafted regulations that would require a transition to zero-emission cargo handling equipment beginning in 2026 with 90% penetration by 2036. The EU has approved a ban of ICE vehicle sales starting in 2035, with an exception for those that use carbon-neutral fuels.

There are also a variety of benefits that can make electric-powered materials handling equipment an attractive solution for certain operations. For one, battery electric forklifts and container handling equipment produce zero tailpipe emissions. Compared to ICE models, electric alternatives produce less noise and vibration, offering a more comfortable experience for the operator.

Electric equipment can also be less expensive to maintain. For example, diesel engines require regular oil changes, usually every 500 or 1,000 hours of use, with each typically requiring multiple gallons or liters of costly oil. Not only are oil changes eliminated, but electric equipment reduces or eliminates many of the other extensive service requirements associated with ICE equipment for the engine, fuel and air filters, transmission and brakes. And as emission standards for ICE equipment get more stringent, there is more emissions-related equipment on ICE trucks to maintain, such as the diesel particulate filter (DPF), diesel exhaust fluid (DEF) system and exhaust gas recirculation components. Because of the reduced components of electric equipment, servicing

a high-voltage truck can be less expensive in some cases than ICE alternatives, even with two technicians required for certain high-voltage tasks.

#### The draw of high voltage

High-voltage battery systems are used on heavy-duty equipment like high-capacity forklifts and container handlers because of physical equipment design considerations, and because they offer productivity benefits that can be advantageous for some operations. From a design perspective, to achieve the necessary power using lower voltage wires, the wires would be thick and heavy enough that their bend radius would not allow them to fit within the frame of the truck. In terms of productivity, higher voltages allow for faster charging compared to lower voltage systems and provide very responsive performance.

As you assess whether high-voltage, high-capacity materials handling equipment is the strongest choice for your operation, working with experienced experts can help you to make an informed decision, understand important safety considerations and access certified technicians for maintenance or repairs. To learn more, contact your local Hyster® dealer or visit [Hyster.com](https://www.hyster.com).