

# Red Seal Occupational Standard

## Industrial Electrician



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# **Red Seal Occupational Standard**

## **Industrial Electrician**



Title: Industrial Electrician

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# Foreword

***The Canadian Council of Directors of Apprenticeship (CCDA) recognizes this Red Seal Occupational Standard (RSOS) as the Red Seal standard for the Industrial Electrician trade.***

## **Background**

The first National Conference on Apprenticeship in Trades and Industries, held in Ottawa in 1952, recommended that the federal government be requested to cooperate with provincial and territorial apprenticeship committees and officials in preparing analyses of a number of skilled occupations. Employment and Social Development Canada (ESDC) sponsors the Red Seal Program, which, under the guidance of the CCDA, develops a national occupational standard for each of the Red Seal trades.

Standards have the following objectives:

- to describe and group the tasks performed by skilled workers;
- to identify which tasks are performed in every province and territory;
- to develop instruments for use in the preparation of Interprovincial Red Seal Examinations and assessment tools for apprenticeship and certification authorities;
- to develop common tools for apprenticeship on-the-job and technical training in Canada;
- to facilitate the mobility of apprentices and skilled workers in Canada;
- to supply employers, employees, associations, industries, training institutions and governments with analyses of occupations.

Any questions, comments, or suggestions for changes, corrections, or revisions to this standard or any of its related products may be forwarded to:

Trades and Apprenticeship Division  
Apprenticeship and Sectoral Initiatives Directorate  
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140 Promenade du Portage, Phase IV, 6th Floor  
Gatineau, Quebec K1A 0J9

# Acknowledgements

The CCDA and ESDC wish to express sincere appreciation for the contribution of the many tradespersons, industrial establishments, professional associations, labour organizations, provincial and territorial government departments and agencies, and all others who contributed to this publication.

Special thanks are offered to Peter Olders, Ontario, who provided expert advice in the initial review.

This standard was prepared by the Apprenticeship and Regulated Occupations Directorate of ESDC. The coordinating, facilitating and processing of this analysis were undertaken by employees of the standards development team of the Trades and Apprenticeship Division and of Ontario, the host jurisdiction for this trade.

# Structure of the Occupational Standard

To facilitate understanding of the occupation, this standard contains the following sections:

**Methodology:** an overview of the process for development, review, validation and weighting of the standard

**Description of the Industrial Electrician trade:** An overview of the trade's duties, work environment, job requirements, similar occupations and career progression

**Trends in the Industrial Electrician trade:** Some of the trends identified by industry as being the most important for workers in this trade

**Essential Skills Summary:** An overview of how each of the 9 essential skills is applied in this trade

**Roles and Opportunities for Skilled Trades in a Sustainable Future:** an overarching description of how in the context of climate change, skilled trades play a large role in implementing solutions and adjusting to changes in the world. In addition to highlighting the importance of this awareness, the standard may also contain more details on activities, skills and knowledge elements that are specific to the trade

**Industry Expected Performance:** a description of the expectations regarding the level of performance of the task, including information related to specific codes, regulations and standards that must be observed

**Language Requirements:** description of the language requirements for working and studying in this trade in Canada

**Pie Chart of Red Seal Examination Weightings:** a graph which depicts the national percentages of exam questions assigned to the major work activities

**Task Matrix:** a chart which outlines graphically the major work activities, tasks and sub tasks of this standard

**Major Work Activity (MWA):** the largest division within the standard that is comprised of a distinct set of trade activities

**Task:** distinct actions that describe the activities within a major work activity

**Task Descriptor:** a general description of the task

**Sub-task:** distinct actions that describe the activities within a task

**Skills:**

**Performance Criteria:** description of the activities that are done as the sub-task is performed

**Evidence of Attainment:** proof that the activities of the sub-task meet the expected performance of a tradesperson who has reached journeyperson level

**Knowledge:**

**Learning Outcomes:** describes what should be learned relating to a sub-task while participating in technical or in-school training

**Learning Objectives:** topics to be covered during technical or in-school training in order to meet the learning outcomes for the sub-task

**Range of Variables:** elements that provide a more in-depth description of a term used in the performance criteria, evidence of attainment, learning outcomes, or learning objectives

**Appendix A – Acronyms:** a list of acronyms used in the standard with their full name

**Appendix B – Tools and Equipment / Outils et équipement:** a non-exhaustive bilingual list of tools and equipment used in this trade

**Appendix C – Glossary / Glossaire:** bilingual definitions or explanations of selected technical terms used in the standard

# Methodology

## Development of the Standard

A draft standard is developed by a broad group of trade representatives, including tradespeople, instructors and employers at a National Workshop led by a team of facilitators. This draft standard breaks down all the tasks performed in the occupation and describes the knowledge and abilities required for a tradesperson to demonstrate competence in the trade.

## Harmonization of Apprenticeship Training

An analysis of all provinces' and territories' apprenticeship programs is performed and recommendations are made on harmonizing the name of the trade, the hours of training required and the number of levels of training. Provinces and territories consult with their respective industry stakeholders on these elements and revisions are discussed until consensus is reached. Following the development of the workshop draft of the RSOS, participants discuss and come to consensus on the sequence of training topics, as expressed in the new standard. Their sequencing recommendations are reviewed by stakeholders in participating provinces and territories and further discussions are convened to reach consensus and to identify any exceptions.

## Online Survey

Stakeholders are asked to review and validate the activities described in the new standard via an online survey. These stakeholders are invited to participate in this consultation through apprenticeship authorities, as well as national stakeholder groups.

## Draft Review

The RSOS development team forwards a copy of the standard and its translation to provincial and territorial authorities who consult with industry representatives to review it. Their recommendations are assessed and incorporated into the standard.

## Validation and Weighting

Participating provinces and territories also consult with industry to validate and weight the document for the purpose of planning the makeup of the Red Seal Interprovincial Examination for the trade. They validate and weight the major work activities (MWA), tasks and sub-tasks, of the standard as follows:

<b>MWA</b>	Each jurisdiction assigns a percentage of questions to each MWA for an examination that would cover the entire trade.
<b>TaskS</b>	Each jurisdiction assigns a percentage of exam questions to each task within a MWA.
<b>SUB-TaskS</b>	Each jurisdiction indicates, with a YES or NO, whether or not each sub-task is performed by skilled workers within the occupation in its jurisdiction.



The results of this exercise are submitted to the RSOS development team who then analyzes the data and incorporates it into the document. The RSOS provides the individual jurisdictional validation results as well as the national averages of all responses. The national averages for MWA and task weighting guide the Interprovincial Red Seal Examination plan for the trade.

The validation of the RSOS is used to identify common core sub-tasks across Canada for the occupation. If at least 70% of the responding jurisdictions' industry performs a sub-task, it shall be considered common core. Interprovincial Red Seal Examination questions are limited to the common core sub-tasks identified through this validation process.

## Definitions for Validation and Weighting

<b>YES</b>	sub-task performed by qualified workers in the occupation in that province or territory
<b>NO</b>	sub-task not performed by qualified workers in the occupation in that province or territory
<b>NV</b>	standard <u>N</u> ot <u>V</u> alidated by that province or territory
<b>ND</b>	trade <u>N</u> ot <u>D</u> esignated in a province or territory
<b>NOT COMMON CORE (NCC)</b>	sub-task, task or MWA performed less than 70% of responding jurisdictions; these will not be tested by the Interprovincial Red Seal Examination for the trade
<b>NATIONAL AVERAGE %</b>	average percentage of questions assigned to each MWA and task in Interprovincial Red Seal Examination for the trade

## Provincial/Territorial Abbreviations

<b>NL</b>	Newfoundland and Labrador
<b>NS</b>	Nova Scotia
<b>PE</b>	Prince Edward Island
<b>NB</b>	New Brunswick
<b>QC</b>	Quebec
<b>ON</b>	Ontario
<b>MB</b>	Manitoba
<b>SK</b>	Saskatchewan
<b>AB</b>	Alberta
<b>BC</b>	British Columbia
<b>NT</b>	Northwest Territories
<b>YT</b>	Yukon Territory
<b>NU</b>	Nunavut

# Description of the Industrial Electrician Trade

“Industrial Electrician” is this trade’s official Red Seal occupational title approved by the CCDA. This standard covers tasks performed by an industrial electrician. Industrial electricians install, maintain, test, troubleshoot, service and repair industrial electrical equipment and associated electrical protection and controls. These include equipment or components directly or indirectly exposed to electrical power such as motors, generators, pumps and lighting systems. Industrial electricians are employed by utilities, electrical contractors and maintenance departments of plants, mines, manufacturing facilities, government and other industrial establishments.

Industrial electricians must read and interpret standards, prints, drawings and codes for layout and installation of electrical equipment. They install, service and maintain electrical components such as lighting fixtures, switches, conduit and electrical controls. They test electrical systems and continuity of circuits using test equipment to ensure system safety and compatibility. They conduct preventative and predictive maintenance programs and keep maintenance records. Industrial electricians may specialize in maintenance functions in areas such as high voltage, building automation and process control.

Industrial electricians must possess manual dexterity, and good planning, organizational and communication skills. They also require strong analytical, mathematical and problem-solving skills in order to read and interpret schematics, drawings and specifications. They should have good mechanical aptitude to install, troubleshoot and repair equipment. It is important for industrial electricians to have a good grasp of digital technology because many of the skills and technology for an industrial electrician are computer based. They must also have good vision and hearing, the ability to distinguish colours and a willingness to upgrade their skills to adapt to new developments in the trade.

The work environment of industrial electricians can expose them to hazards. Their work is performed indoors or outdoors in diverse climate conditions, and may be at variable heights or in confined spaces. Occupational risks include electrical shocks, arc flashes, falls, and injury from lifting and kneeling.

This occupational standard recognizes similarities or overlaps with the work of construction electricians, powerline technicians, instrumentation and control technicians, electric motor systems technicians, heating, ventilation and air conditioning (HVAC) technicians, telecommunications technicians and industrial mechanics (millwrights). Industrial electricians also work with process operators, engineers and inspectors.

With experience, industrial electricians may act as mentors and trainers to apprentices in the trade. They may also advance to managerial, inspection, facilitation or teaching positions.

# Trends in the Industrial Electrician Trade

## Technology

Technological advancements have improved the way industrial electricians perform their work on a daily basis. Digital technology is increasingly being used for research, communication, programming, ordering, record keeping and diagnostics. New types of test equipment, along with equipment becoming more user-friendly, has reduced the time it takes to diagnose and troubleshoot problems. Also emerging are cloud based monitoring and diagnostic systems. Control and monitoring of electrical equipment is starting to migrate to both wired such as Power over Ethernet (PoE) and wireless technology utilizing the platform of Internet of Things (IoT) or the industrial version (IIoT).

Under the 'Industry 4.0' banner a developing interconnecting technology, Power over Data Lines (PoDL) of Single Balanced Twisted-Pair Ethernet is poised to first emerge in the industrial electrical setting as an effective interconnect method for IIoT devices. In the industrial wireless realm, there is an adoption of more robust and wider bandwidth technologies such as Wi-Fi 6, Wi-Fi 6E and 5G.

Along with these interconnecting methods is a technologically safer method of distributing power via Fault Managed Power (FMP) utilizing pulsed power or packet energy transfer.

A promising technology is the solid-state overcurrent protection device that permits very fast activation, thereby greatly reducing arc flash hazards and potential equipment damage. Another disrupter technology is motors and generators that use a printed circuit stator, allowing for thin, compact and lighter (up to 70%) motors with equal torque and thermal performance of traditional steel stator motors.

In the maintenance of industrial electrical equipment and systems, inspection and evaluation is evolving into a more critical area of focus. In fact, inspection is gaining more importance in assuring the health and safety of employees and the continued reliable operation of machinery and components.

Predictive and preventative maintenance programs, using computerized maintenance management systems (CMMSs), are becoming more prevalent in the workplace. These systems have enhanced efficiency and organization of the tasks required for maintenance of electrical systems. They also centralize other functions such as trends, component ordering, project control, history, costing, work hours and tool cribs.

Programmable logic controllers (PLCs), supervisory control and data acquisition systems (SCADA) and distributed control systems (DCSs) facilitate the monitoring and control of utility or industrial processes and controls. This equipment has become more pervasive. Smaller units are readily available for a variety of applications. Human machine interface (HMI) is becoming more integrated to the control systems. Industrial electricians work increasingly less with hardwired devices.

Reliability centered maintenance and process safety management including safety instrumented systems (SIS) such as safety PLCs, light curtains and area scanners in the industry has resulted in a change in focus and in the duties of industrial electricians.

Digital technology has facilitated the use of new components, making the tracking of energy usage more reliable and efficient. It is simpler to replace many of the old parts and devices now that they are smaller and available in digital format. Data communications has evolved from multiple protocols (data highways, DeviceNet, Modbus, distributed network protocol [DNP], IEC 61850, advanced distribution management system [ADMS]) to being harmonized on a global ethernet protocol. Industrial electricians need to constantly upgrade their knowledge of this technology.

Industry in Canada is moving towards efficient and environmentally friendly techniques and energy saving devices, solid state lighting (SSL) such as light emitting diode (LED) lighting, automated lighting control and variable speed drives. Industrial electricians need to be aware of governmental programs, regulations and energy saving initiatives. Industrial electricians may also be involved in the installation and maintenance of renewable energy systems such as solar and wind, and their associated energy storage systems.

In many sectors of industry, robotic technology is being utilized. Therefore, some industrial electricians are now required to develop specialized skills to keep abreast of this technology.

## **Safety and environmental considerations**

The combination of various factors in the presence of a fault may cause an electrocution, arc flash and blast which could result in extreme burns, serious injury or death. Injuries caused by arc flash have led to heightened safety measures. New practices, procedures, safety equipment and jurisdictional regulations have been created and implemented in order to address the issue.

The parameters of work for industrial electricians have increased in process control, environmental control and building automation systems. There is now an increased emphasis on accountability for safety in the workplace.

Many of the facilities that employ industrial electricians are starting to migrate to a more sustainable environment. These include 'Net Zero' (carbon neutral) facilities that are striving to reduce their carbon footprint. Carbon neutral may involve either or both lower carbon emission or lower energy consumption. Technologies required to achieve these goals include renewable energy, energy storage, and building automation to monitor and control energy production and consumption. Along with lowering the carbon footprint comes a complementary environment initiative to 'reuse and recycle'. More suppliers are initiating 'Takeback Programs' to assist facility owners with recycling their obsolete electrical components.

# Essential Skills Summary

Essential skills are needed for work, learning and life. They provide the foundation for learning all other skills and enable people to evolve with their jobs and adapt to workplace change.

Through extensive research, the Government of Canada and other national and international agencies have identified and validated nine essential skills. These skills are used in nearly every occupation and throughout daily life in different ways.

The application of these skills may be described throughout this document within the skills and knowledge which support each sub-task of the trade. The following are summaries of the requirements in each of the essential skills, taken from the essential skills profile.

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## Reading

In their daily work, industrial electricians read and comprehend several types of text. These include work orders, safety and workplace documents as well as more complex technical electrical codes, regulations and equipment manuals.

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## Document use

Industrial electricians must use workplace documents such as electrical diagrams and schematic drawings, Safety Data Sheets (SDS) and shift schedules. They must be familiar with electrical codes. It is necessary for industrial electricians to seek service and repair information from manuals and other sources.

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## Writing

Industrial electricians use writing skills to record comments or notes in logbooks or work records. They write messages to colleagues or management to give work details or reply to requests for technical information. They also write longer service reports to describe problems and their solutions.

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## Oral communication

Industrial electricians use oral communication skills to coordinate work with production crews and equipment operators. Clear communication of technical and complex information is very important to avoid injuries and promote efficiency. Industrial electricians also use communication skills when working with co-workers and supervisors, and mentoring apprentices in the trade. Good listening skills are also required of industrial electricians for comprehension and understanding such as the ability to repeat back clearly what has been stated or learned.

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## Numeracy

Industrial electricians use a range of complex math skills in their day to day work. These include scheduling, measurement, conversions and calculations. They use electrical theory by applying formulas from electrical codes to determine equipment and wiring specifications and to analyze measurements.

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## **Thinking**

Industrial electricians require strong analytical skills to troubleshoot and diagnose malfunctions in equipment. They use logic and memory to determine the faults. They must use decision-making skills to perform work planning and prioritizing. Decisions about when to perform shut-downs have important implications on safety in their workplace.

Industrial electricians organize the most effective use of their time within the framework of assigned tasks. Routine tasks are generally assigned by supervisors or dictated by a procedure established by the employer. Much of their other work is in response to broken or malfunctioning equipment. They often have to re-prioritize tasks several times a day. Industrial electricians coordinate their work with other trades and production staff, all of whom have different needs and priorities.

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## **Digital technology**

Skills in digital technology are increasingly important for industrial electricians. They use general applications such as e-mails, Internet, word processing, databases and original equipment manufacturer (OEM) software to communicate, perform research, organize their work and configure and update electrical equipment operating parameters. More trade specific applications include computer assisted design (CAD) and computer-aided manufacturing (CAM) software and logic controllers.

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## **Working with others**

Industrial electricians work as part of a team that includes other tradespeople and professionals to install, repair and maintain industrial electrical systems and equipment. They most often work independently, coordinating their work with the work of others, but for large jobs they work with a partner or crew.

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## **Continuous learning**

Industrial electricians often receive in-house safety training to update their certifications such as Workplace Hazardous Materials Information System (WHMIS), transportation of dangerous goods (TDG), First Aid and cardiopulmonary resuscitation (CPR). They also receive training so that they can safely operate equipment such as forklifts, scissor lifts and scaffolding. They learn about new equipment on the job by reading manuals, taking courses and through hands-on experience. They obtain computer training by taking courses off-site and through e-learning.

# Roles and Opportunities for Skilled Trades in a Sustainable Future

Climate change affects all of us. Trades play a large role in implementing solutions and adjusting to changes in the world.

Throughout this standard, there may be specific references to tasks, skills and knowledge that clearly show this trade's role in a more sustainable future. Each trade has different roles to play and contributions to make in their own way.

For example:

- Construction tradespeople need to consider the materials they are using, building methods, and improvements to mechanical and electrical installations. There are important changes to codes and standards to help meet the climate change goals and commitments set for 2030 and 2050. Retrofits and new construction of low-energy buildings provide enormous opportunities for workers in this sector. Concepts, such as energy efficiency and regarding buildings as systems are foundational.
- Automotive and mechanical trades are seeing a shift towards the electrification of vehicles and equipment. As a result, new skills and knowledge will be required for tradespeople working in this sector. There are mandates for sales of new light-duty zero-emission vehicles (ZEV) in Canada, with the goal of achieving 100% ZEV sales by 2035. Due to this mandate, the demand for these vehicles is growing quickly among consumers and fleets. With this escalating demand, the need for skilled workers to maintain and repair these vehicles is also increasing.
- In industrial and resource sectors, there is pressure to move towards increased electrification of industrial processes. Many industrial and commercial facilities are also being upgraded to improve energy efficiency in areas such as lighting systems, and new production processes and technologies. There are also opportunities in carbon capture, utilization and storage (CCUS), as well as the production and export of low-carbon hydrogen.
- Trades in the service sector may also need to be aware of responsible sourcing, as well as efficient use of products and materials. New ways of working better are always a part of the job.

There are fast-moving changes in guidelines, codes, regulations and specifications. Many are being implemented for the purpose of energy efficiency and climate change. Those that affect specific trades may be mentioned within the standard. Examples of these guidelines and legislation include:

- The National Energy Code of Canada for Buildings (NECB).
- The Canadian Net-Zero Emissions Accountability Act (CNZEEA).
- programs that encourage sustainable building design and construction such as Leadership in Energy and Environmental Design (LEED) and the Zero Carbon Building (ZCB) standards.
- the Montreal Protocol for phasing out R22 refrigerants.
- energy efficiency programs such as ENERGY STAR.



- principles of the United Nations Declaration for the Rights of Indigenous Peoples pertaining to energy sector development.

Apprentices and tradespeople need to increase their climate literacy and reinforce their own understanding of energy issues and environmental practices. It is important for them to understand why these changes are happening and their effect on trades' work. While individual tradespeople and apprentices may not be able to choose certain elements like; the architectural design of buildings, building material selection, regulatory requirements, use of electric vehicles and technologies, they must understand the impact of using these elements in their work. Impacts include using environmentally friendly products and following requirements related to the disposal and recycling of materials.

In apprenticeship, as well as in ongoing professional development, employers and instructors should encourage learning about these concepts, why they are important, how they are implemented, and the overarching targets they are aiming to achieve.

All in all, it's about doing the work better and building a better world.

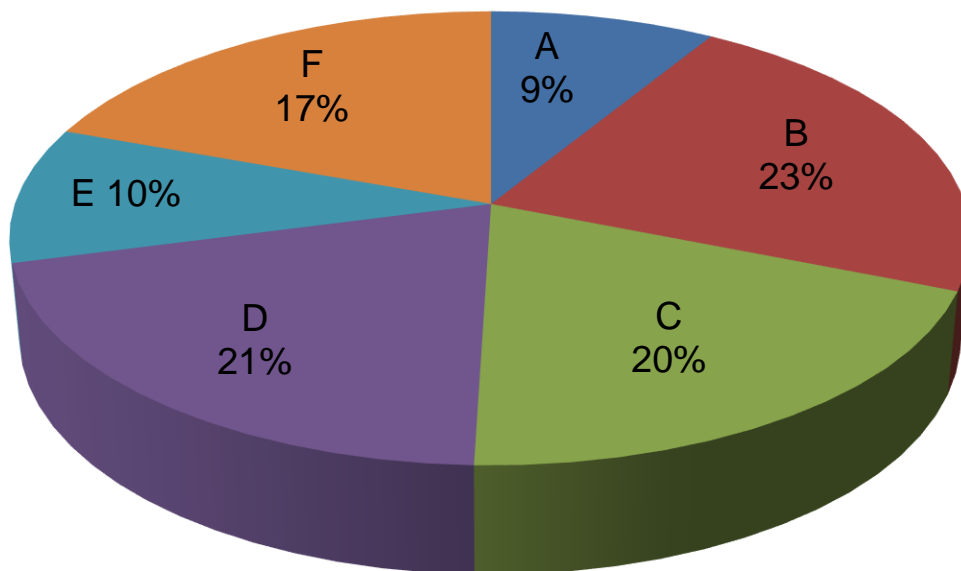
# Industry Expected Performance

All tasks must be performed according to the applicable jurisdictional codes and standards. All health and safety standards must be respected and observed. Work should be done efficiently and at a high quality without material waste or environmental harm. All requirements of employers, engineers, designers, manufacturers, clients and quality control policies must be met. At a journeyperson level of performance, all tasks must be done with minimal direction and supervision. As a journeyperson progresses in their career there is an expectation they continue to upgrade their skills and knowledge to maintain pace with industry and promote continuous learning in their trade through mentoring of apprentices.

# Language Requirements

It is expected that journeypersons are able to understand and communicate in either English or French, which are Canada's official languages. English or French are the common language of business as well as language of instruction in apprenticeship programs.

# Pie Chart of Red Seal Examination Weightings



MWA A	Performs Common Occupational Skills	9%
MWA B	Installs and Maintains Generating, Distribution and Service Systems	23%
MWA C	Installs and Maintains Wiring Systems	20%
MWA D	Installs and Maintains Rotating and Other Fixed Equipment and Control Systems	21%
MWA E	Installs and Maintains Signalling and Communication Systems	10%
MWA F	Installs and Maintains Process Control Systems	17%

This pie chart represents a breakdown of the interprovincial Red Seal examination. Percentages are based on the collective input from workers from the trade from across Canada. The Task Matrix on the next pages indicates the breakdown of tasks and sub-tasks within each Major Work Activity and the breakdown of questions assigned to the Tasks. The Interprovincial examination for this trade has 100 questions.

# Industrial Electrician

## Task Matrix and Weightings

### A - Performs common occupational skills

9%

<b>Task A-1</b> <b>Performs safety-related functions</b> <b>22%</b>	A-1.01 Maintains safe work environment	A-1.02 Uses personal protective equipment (PPE) and safety equipment	A-1.03 Performs lock-out and tag-out procedures
	A-1.04 Identifies environmental conditions		
<b>Task A-2</b> <b>Uses tools and equipment</b> <b>18%</b>	A-2.01 Uses common and specialty tools and equipment	A-2.02 Uses access equipment	A-2.03 Uses rigging, hoisting and lifting equipment
<b>Task A-3</b> <b>Organizes work</b> <b>18%</b>	A-3.01 Interprets plans, drawings and specifications	A-3.02 Identifies hazardous installations	A-3.03 Organizes materials and supplies
	A-3.04 Plans project tasks and procedures	A-3.05 Prepares specific location in facility	A-3.06 Finalizes required documentation
<b>Task A-4</b> <b>Fabricates and installs support components</b> <b>15%</b>	A-4.01 Fabricates support structures	A-4.02 Installs brackets, hangers and fasteners	A-4.03 Installs seismic restraint systems
<b>Task A-5</b> <b>Commissions and decommissions electrical systems</b> <b>21%</b>	A-5.01 Commissions systems	A-5.02 Performs shutdown and startup procedures	A-5.03 Decommissions systems
<b>Task A-6</b> <b>Uses communication and mentoring techniques</b> <b>6%</b>	A-6.01 Uses communication techniques	A-6.02 Uses mentoring techniques	

## B - Installs and maintains generating, transmission, distribution and service systems

23%

<p><b>Task B-7</b> Installs and maintains utility and non-utility supply services and metering equipment <b>11%</b></p>	<p><b>B-7.01</b> Installs single-phase utility and non-utility supply services and metering equipment</p>	<p><b>B-7.02</b> Maintains single-phase utility and non-utility supply services and metering equipment</p>	<p><b>B-7.03</b> Installs three-phase utility and non-utility supply services and metering equipment</p>
	<p><b>B-7.04</b> Maintains three-phase utility and non-utility supply services and metering equipment</p>		
<p><b>Task B-8</b> Installs and maintains protection devices <b>16%</b></p>	<p><b>B-8.01</b> Installs overcurrent protection devices</p>	<p><b>B-8.02</b> Maintains overcurrent protection devices</p>	<p><b>B-8.03</b> Installs ground fault, arc fault and surge protection devices</p>
	<p><b>B-8.04</b> Maintains ground fault, arc fault and surge protection devices</p>	<p><b>B-8.05</b> Installs under- and over-voltage protection devices</p>	<p><b>B-8.06</b> Maintains under- and over-voltage protection devices</p>
<p><b>Task B-9</b> Installs and maintains low-voltage distribution systems <b>14%</b></p>	<p><b>B-9.01</b> Installs low-voltage distribution equipment</p>	<p><b>B-9.02</b> Maintains low-voltage distribution equipment</p>	
<p><b>Task B-10</b> Installs and maintains power conditioning systems <b>10%</b></p>	<p><b>B-10.01</b> Installs power conditioning systems</p>	<p><b>B-10.02</b> Maintains power conditioning systems</p>	
<p><b>Task B-11</b> Installs and maintains bonding, grounding and ground-fault protection and detection systems <b>12%</b></p>	<p><b>B-11.01</b> Installs grounding systems</p>	<p><b>B-11.02</b> Maintains grounding systems</p>	<p><b>B-11.03</b> Installs bonding systems</p>
	<p><b>B-11.04</b> Maintains bonding systems</p>	<p><b>B-11.05</b> Installs ground-fault protection and detection systems</p>	<p><b>B-11.06</b> Maintains ground-fault protection and detection systems</p>

<b>Task B-12</b> <b>Installs and maintains power generating and conversion systems</b> <b>9%</b>	<b>B-12.01 Installs alternating current (AC) generating systems</b>	<b>B-12.02 Maintains alternating current (AC) generating systems</b>	<b>B-12.03 Installs direct current (DC) generating and conversion systems</b>
	<b>B-12.04 Maintains direct current (DC) generating and conversion systems</b>		
<b>Task B-13</b> <b>Installs and maintains renewable energy generating and energy storage systems</b> <b>6%</b>	<b>B-13.01 Installs renewable energy generating and energy storage systems</b>	<b>B-13.02 Maintains renewable energy generating and energy storage systems</b>	
<b>Task B-14</b> <b>Installs and maintains high-voltage systems</b> <b>10%</b>	<b>B-14.01 Installs high-voltage systems</b>	<b>B-14.02 Maintains high-voltage systems</b>	
<b>Task B-15</b> <b>Installs and maintains transformers</b> <b>12%</b>	<b>B-15.01 Installs extra-low-voltage transformers</b>	<b>B-15.02 Maintains extra-low-voltage transformers</b>	<b>B-15.03 Installs low-voltage single-phase transformers</b>
	<b>B-15.04 Maintains low-voltage single-phase transformers</b>	<b>B-15.05 Installs low-voltage three-phase transformers</b>	<b>B-15.06 Maintains low-voltage three-phase transformers</b>
	<b>B-15.07 Installs high-voltage transformers</b>	<b>B-15.08 Maintains high-voltage transformers</b>	

## C - Installs and maintains wiring systems

20%

<p><b>Task C-16</b> Installs and maintains raceways, cables, conductors and enclosures <b>26%</b></p>	<p><b>C-16.01</b> Installs conductors and cables</p>	<p><b>C-16.02</b> Maintains conductors and cables</p>	<p><b>C-16.03</b> Installs conduit, tubing and fittings</p>
<p><b>Task C-17</b> Installs and maintains branch circuitry and devices <b>26%</b></p>	<p><b>C-16.04</b> Installs raceways</p>	<p><b>C-16.05</b> Installs boxes and enclosures</p>	<p><b>C-16.06</b> Maintains conduit, tubing, fittings, raceways, boxes and enclosures</p>
<p><b>Task C-18</b> Installs and maintains heating, ventilation and air-conditioning (HVAC) electrical components <b>14%</b></p>	<p><b>C-17.01</b> Installs luminaires</p>	<p><b>C-17.02</b> Maintains luminaires</p>	<p><b>C-17.03</b> Installs wiring devices</p>
<p><b>Task C-19</b> Installs and maintains electric heating systems and controls <b>15%</b></p>	<p><b>C-17.04</b> Maintains wiring devices</p>	<p><b>C-18.01</b> Connects power to heating, ventilation and air-conditioning (HVAC) systems and associated equipment</p>	<p><b>C-18.02</b> Installs heating, ventilation and air-conditioning (HVAC) controls</p>
<p><b>Task C-20</b> Installs and maintains exit and emergency lighting systems <b>12%</b></p>	<p><b>C-18.03</b> Maintains heating, ventilation and air-conditioning (HVAC) electrical components</p>	<p><b>C-19.01</b> Installs electric heating systems and controls</p>	<p><b>C-19.02</b> Maintains electric heating systems and controls</p>
<p><b>Task C-21</b> Installs and maintains cathodic protection systems <b>7%</b></p>	<p><b>C-20.01</b> Installs exit and emergency lighting systems</p>	<p><b>C-20.02</b> Maintains exit and emergency lighting systems</p>	
	<p><b>C-21.01</b> Installs cathodic protection systems</p>	<p><b>C-21.02</b> Maintains cathodic protection systems</p>	



## D - Installs and maintains rotating and other fixed equipment and control systems

**21%**

<b>Task D-22</b> Installs and maintains motor starters and control devices <b>34%</b>	D-22.01 Installs motor starters	D-22.02 Maintains motor starters	D-22.03 Installs motor control devices
	D-22.04 Maintains motor control devices		
<b>Task D-23</b> Installs and maintains drives <b>23%</b>	D-23.01 Installs alternating current (AC) drives	D-23.02 Maintains alternating current (AC) drives	D-23.03 Installs direct current (DC) drives
	D-23.04 Maintains direct current (DC) drives		
<b>Task D-24</b> Installs and maintains other fixed equipment and associated controls <b>14%</b>	D-24.01 Installs other fixed equipment and associated controls	D-24.02 Maintains other fixed equipment and associated controls	
<b>Task D-25</b> Installs and maintains motors <b>29%</b>	D-25.01 Installs single-phase motors	D-25.02 Maintains single-phase motors	D-25.03 Installs three-phase motors
	D-25.04 Maintains three-phase motors	D-25.05 Installs direct current (DC) motors	D-25.06 Maintains direct current (DC) motors

## E - Installs and maintains signalling and communication systems

10%

<b>Task E-26</b> Installs and maintains signalling systems <b>35%</b>	<b>E-26.01 Installs fire alarm systems</b>	<b>E-26.02 Maintains fire alarm systems</b>	<b>E-26.03 Installs security and surveillance systems</b>
	<b>E-26.04 Maintains security and surveillance systems</b>		
<b>Task E-27</b> Installs and maintains communication systems <b>32%</b>	<b>E-27.01 Installs communication systems</b>	<b>E-27.02 Maintains communication systems</b>	
<b>Task E-28</b> Installs and maintains building automation systems <b>33%</b>	<b>E-28.01 Installs building automation systems</b>	<b>E-28.02 Maintains building automation systems</b>	

## F - Installs and maintains process control systems

**17%**

<b>Task F-29</b> Installs and maintains input/output (I/O) devices <b>48%</b>	F-29.01 Installs discrete input/output (I/O) devices	F-29.02 Maintains discrete input/output (I/O) devices	F-29.03 Installs analog input/output (I/O) devices
	F-29.04 Maintains analog input/output (I/O) devices		
<b>Task F-30</b> Installs, programs and maintains automated control systems <b>37%</b>	F-30.01 Installs automated control systems	F-30.02 Maintains automated control systems	F-30.03 Programs automated control systems
	F-30.04 Optimizes system performance		
<b>Task F-31</b> Installs and maintains pneumatic and hydraulic control systems <b>15%</b>	F-31.01 Installs pneumatic control systems	F-31.02 Maintains pneumatic control systems	F-31.03 Installs hydraulic control systems
	F-31.04 Maintains hydraulic control systems		

# Harmonization of Apprenticeship Training

Provincial and territorial apprenticeship authorities are each responsible for their respective apprenticeship programs. In the spirit of continual improvement, and to facilitate mobility among apprentices in Canada, participating authorities have agreed to work towards harmonizing certain aspects of their programs where possible. After consulting with their stakeholders in the trade, they have reached consensus on the following elements. Note that implementation of these elements may vary from jurisdiction to jurisdiction, depending on their own circumstances. For more information on the implementation in any province and territory, please contact that jurisdiction’s apprenticeship authority.

## 1. Trade name

The official Red Seal name for this trade is Industrial Electrician.

## 2. Number of Levels of Apprenticeship

The number of levels of technical training recommended for this trade is 4 (four).

## 3. Total Training Hours During Apprenticeship Training

The total hours of training, including both on-the-job and in-school training for this trade is 7200.

## 4. Sequencing Topics and Related Sub-tasks

The topic titles in the table below are placed in a column for each apprenticeship level for technical training. Each topic is accompanied by the sub-tasks and their reference number. The topics in the grey shaded cells represent those that are covered “in context” with other training in the subsequent years.

Level 1	Level 2	Level 3	Level 4
	Context	Context	Context
	Organizes Work	Organizes Work	Organizes Work
	Support Components	Support Components	Support Components
	Electrical Systems (Commissions and Decommissions)	Electrical Systems (Commissions and Decommissions)	Electrical Systems (Commissions and Decommissions)
	Protection Devices	Protection Devices	Protection Devices
		Raceways, Cables, Conductors and Enclosures	Raceways, Cables, Conductors and Enclosures

**Safety-Related Functions**  
**1.01 Maintains safe work environment**  
**1.02 Uses personal protective equipment (PPE) and safety equipment**  
**1.03 Performs lock-out and tag-out procedures**  
**1.04 Identifies environmental conditions**

Level 1	Level 2	Level 3	Level 4
<b>Tools and Equipment</b> 2.01 Uses common and specialty tools and equipment 2.02 Uses access equipment 2.03 Uses rigging, hoisting and lifting equipment			
<b>Organizes Work</b> 3.01 Interprets plans, drawings and specifications 3.02 Identifies hazardous installations 3.03 Organizes materials and supplies 3.04 Plans project tasks and procedures 3.05 Prepares specific location in facility 3.06 Finalizes required documentation			
<b>Support Components</b> 4.01 Fabricates support structures 4.02 Installs brackets, hangers and fasteners 4.03 Installs seismic restraint systems			
<b>Electrical Systems (Commissions and Decommissions)</b> 5.01 Commissions systems 5.02 Performs shutdown and startup procedures 5.03 Decommissions systems			
<b>Communication Techniques</b> 6.01 Uses communication techniques			<b>Mentoring Techniques</b> 6.02 Uses mentoring techniques
<b>Utility and non-Utility/Supply Services and Metering Equipment</b> 7.01 Installs single-phase utility and non-utility/supply services and metering equipment 7.02 Maintains single-phase utility and non-utility/supply services and metering equipment		<b>Utility and non-Utility/Supply Services and Metering Equipment</b> 7.03 Installs three-phase utility and non-utility/supply services and metering equipment 7.04 Maintains three-phase utility and non-utility/supply services and metering equipment	

Level 1	Level 2	Level 3	Level 4
<p><b>Protection Devices</b>  <b>8.01</b> Installs overcurrent protection devices  <b>8.02</b> Maintains overcurrent protection devices  <b>8.03</b> Installs ground fault, arc fault and surge protection devices  <b>8.04</b> Maintains ground fault, arc fault and surge protection devices  <b>8.05</b> Installs under-and-over voltage protection devices  <b>8.06</b> Maintains under-and-over voltage protection devices</p>			
<p><b>Low-Voltage Distribution Systems</b>  <b>9.01</b> Installs low-voltage distribution equipment  <b>9.02</b> Maintains low-voltage distribution equipment</p>		<p><b>Low-Voltage Distribution Systems</b>  <b>9.01</b> Installs low-voltage distribution equipment  <b>9.02</b> Maintains low-voltage distribution equipment</p>	
			<p><b>Power Conditioning Systems</b>  <b>10.01</b> Installs power conditioning systems  <b>10.02</b> Maintains power conditioning systems</p>
<p><b>Bonding and Grounding and Ground-Fault Protection and Detection Systems</b>  <b>11.01</b> Installs grounding systems  <b>11.03</b> Installs bonding systems</p>	<p><b>Bonding and Grounding and Ground-Fault Protection and Detection Systems</b>  <b>11.01</b> Installs grounding systems  <b>11.02</b> Maintains grounding systems  <b>11.03</b> Installs bonding systems  <b>11.04</b> Maintains bonding systems  <b>11.05</b> Installs ground-fault protection and detection systems</p>	<p><b>Bonding and Grounding and Ground-Fault Protection and Detection Systems</b>  <b>11.01</b> Installs grounding systems  <b>11.02</b> Maintains grounding systems  <b>11.03</b> Installs bonding systems  <b>11.04</b> Maintains bonding systems  <b>11.05</b> Installs ground-fault protection and detection systems</p>	<p><b>Bonding and Grounding and Ground-Fault Protection and Detection Systems</b>  <b>11.06</b> Maintains ground-fault protection and detection systems</p>
	<p><b>Power Generating and Conversion Systems</b>  <b>12.03</b> Installs direct current (DC) generating and conversion systems  <b>12.04</b> Maintains DC generating and conversion systems</p>	<p><b>Power Generating and Conversion Systems</b>  <b>12.01</b> Installs alternating current (AC) generating systems  <b>12.02</b> Maintains AC generating systems</p>	

Level 1	Level 2	Level 3	Level 4
	<b>Renewable Energy Generating and Energy Storage Systems</b> 13.01 Installs renewable energy generating and energy storage systems 13.02 Maintains renewable energy generating and energy storage systems		<b>Renewable Energy Generating and Energy Storage Systems</b> 13.01 Installs renewable energy generating and energy storage systems 13.02 Maintains renewable energy generating and energy storage systems
			<b>High-Voltage Systems</b> 14.01 Installs high-voltage systems 14.02 Maintains high-voltage systems
	<b>Transformers</b> 15.01 Installs extra-low voltage transformers 15.02 Maintains extra-low voltage transformers 15.03 Installs low voltage single-phase transformers 15.04 Maintains low voltage single-phase transformers	<b>Transformers</b> 15.05 Installs low voltage three-phase transformers 15.06 Maintains low voltage three-phase transformers 15.07 Installs high voltage transformers. 15.08 Maintains high voltage transformers	
<b>Raceways, Cables, Conductors and Enclosures</b> 16.01 Installs conductors and cables 16.02 Maintains conductors and cables 16.03 Installs conduit, tubing and fittings 16.04 Installs raceways 16.05 Installs boxes and enclosures 16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures	<b>Raceways, Cables, Conductors and Enclosures</b> 16.01 Installs conductors and cables 16.02 Maintains conductors and cables 16.03 Installs conduit, tubing and fittings 16.04 Installs raceways 16.05 Installs boxes and enclosures 16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures		
<b>Branch Circuitry and Devices</b> 17.01 Installs luminaires 17.02 Maintains luminaires 17.03 Installs wiring devices 17.04 Maintains wiring devices	<b>Branch Circuitry and Devices</b> 17.01 Installs luminaires 17.02 Maintains luminaires 17.03 Installs wiring devices 17.04 Maintains wiring devices	<b>Branch Circuitry and Devices</b> 17.01 Installs luminaires 17.02 Maintains luminaires 17.03 Installs wiring devices 17.04 Maintains wiring devices	
	<b>HVAC Electrical Components</b> 18.01 Connects power to HVAC systems and associated equipment 18.02 Installs HVAC controls 18.03 Maintains HVAC electrical components		

Level 1	Level 2	Level 3	Level 4
	<p><b>Electric Heating Systems and Controls</b>  <b>19.01</b> Installs electric heating systems and controls  <b>19.02</b> Maintains electric heating systems and controls</p>		
	<p><b>Exit and Emergency Lighting Systems</b>  <b>20.01</b> Installs exit and emergency lighting systems  <b>20.02</b> Maintains exit and emergency lighting systems</p>		
	<p><b>Cathodic Protection Systems</b>  <b>21.01</b> Installs cathodic protection systems  <b>21.02</b> Maintains cathodic protection systems</p>		
	<p><b>Motors, Starters and Control Devices</b>  <b>22.01</b> Installs motor starters  <b>22.02</b> Maintains motor starters  <b>22.03</b> Installs motor control devices  <b>22.04</b> Maintains motor control devices</p>	<p><b>Motors, Starters and Control Devices</b>  <b>22.01</b> Installs motor starters  <b>22.02</b> Maintains motor starters  <b>22.03</b> Installs motor control devices  <b>22.04</b> Maintains motor control devices</p>	
		<p><b>Drives</b>  <b>23.01</b> Installs AC drives  <b>23.02</b> Maintains AC drives  <b>23.03</b> Installs DC drives  <b>23.04</b> Maintains DC drives</p>	
			<p><b>Other Fixed Equipment and Associated Controls</b>  <b>24.01</b> Installs other fixed equipment and associated controls  <b>24.02</b> Maintains other fixed equipment and associated controls</p>
	<p><b>Motors</b>  <b>25.05</b> Installs DC motors  <b>25.06</b> Maintains DC motors</p>	<p><b>Motors</b>  <b>25.01</b> Installs single-phase motors  <b>25.02</b> Maintains single-phase motors  <b>25.03</b> Installs three-phase motors  <b>25.04</b> Maintains three-phase motors  <b>25.05</b> Installs DC motors  <b>25.06</b> Maintains DC motors</p>	<p><b>Motors</b>  <b>25.01</b> Installs single-phase motors  <b>25.02</b> Maintains single-phase motors  <b>25.03</b> Installs three-phase motors  <b>25.04</b> Maintains three-phase motors  <b>25.05</b> Installs DC motors.  <b>25.06</b> Maintains DC motors</p>



Level 1	Level 2	Level 3	Level 4
<b>Communication Systems</b> 27.01 Installs communications systems 27.02 Maintains communication systems			<b>Signalling Systems</b> 26.01 Installs fire alarm systems 26.02 Maintains fire alarm systems 26.03 Installs security and surveillance systems 26.04 Maintains security and surveillance systems
			<b>Communication Systems</b> 27.02 Maintains communication systems
			<b>Building Automation Systems</b> 28.01 Installs building automation systems 28.02 Maintains building automation systems
			<b>Input/Output (I/O) Devices</b> 29.01 Installs discrete Input/output (I/O) devices 29.02 Maintains discrete Input/output (I/O) devices 29.03 Installs analog Input/output (I/O) devices 29.04 Maintains analog Input/output (I/O) devices
			<b>Automated Control Systems</b> 30.01 Installs automated control systems 30.02 Maintains automated control systems 30.03 Programs automated control systems 30.04 Optimizes system performance
			<b>Pneumatic and Hydraulic Control Systems</b> 31.01 Installs pneumatic control systems 31.02 Maintains pneumatic control systems 31.03 Installs hydraulic control systems 31.04 Maintains hydraulic control systems

# Major Work Activity A

## Performs common occupational skills

### Task A-1 Performs safety-related functions

#### Task Descriptor

Industrial electricians are responsible for ensuring the safety of themselves and others in the work environment. They must use appropriate personal protective equipment (PPE) and follow workplace safety protocols according to their work, facility and jurisdictional regulations.

It is critical that industrial electricians be constantly aware of their surroundings and the hazards they may encounter. They are required to perform lock-out and tag-out on all sources of energy (electrical, pneumatic and hydraulic). Industrial electricians must ensure that the electrical installation follows Canadian Electrical Code (CEC) and authorities having jurisdiction (AHJ). Industrial electricians need to be aware and follow proper disposal methods for environmentally hazardous materials.

#### A-1.01 Maintains safe work environment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-1.01.01P	perform housekeeping practices	work area is clean and clutter-free
A-1.01.02P	identify, report and eliminate potential and existing <b>hazards</b>	<b>hazards</b> are identified, reported and mitigated according to Occupational Health and Safety (OH&S), and facility policies
A-1.01.03P	set up <b>barriers</b> and <b>signage</b> to identify <b>hazards</b> and <b>designated substances</b>	<b>hazards</b> and <b>designated substances</b> are well marked by <b>barriers</b> and <b>signage</b>
A-1.01.04P	store materials and equipment	materials and equipment are stored in designated areas according to Workplace Hazardous Materials Information Sheets (WHMIS), facility policies and practices, and AHJ requirements
A-1.01.05P	identify and respect physical limitations of self and others	physical limitations of self and others are identified and work is performed according to them

A-1.01.06P	set up and identify locations containing <b>safety components</b>	locations containing <b>safety components</b> are identified with signage and on jobsite map
A-1.01.07P	follow safe work practices	safe work practices are followed according to OH&S and facility policies
A-1.01.08P	identify <b>designated substances</b> hazardous to personnel	<b>designated substances</b> are identified according to material and equipment labels and product documentation
A-1.01.09P	contain <b>designated substances</b>	<b>designated substances</b> are contained and disposed of according to jurisdictional regulations and facility policy

## Range of Variables

**hazards** include: arc flash, arc blast, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation, open holes, confined space, fire, tripping hazards, overhead work, heights, SF<sub>6</sub> gas

**barriers** and **signage** include: caution and danger tapes, fences, tags, signs, barricades

**safety components** include: first aid kits, fire extinguishers, safety data sheets (SDS), emergency eye wash stations, automated external defibrillator (AED), confined space rescue equipment

**designated substances** include: acrylonitrile, arsenic, asbestos, benzene, coke oven emissions, ethylene oxide, isocyanates, lead, mercury, silica, vinyl chloride, SF<sub>6</sub> gas, H<sub>2</sub>S gas

## Knowledge

	Learning Outcomes	Learning Objectives
A-1.01.01L	demonstrate knowledge of safe work practices	identify <b>hazards</b> and describe safe work practices
A-1.01.02L	demonstrate knowledge of regulatory requirements pertaining to <b>hazards</b> and <b>emergency situations</b>	identify and interpret regulatory requirements pertaining to <b>hazards</b> and <b>emergency situations</b>
A-1.01.03L	demonstrate knowledge of containment methods	describe containment methods for <b>designated substances</b>
A-1.01.04L	demonstrate knowledge of procedures used in <b>emergency situations</b>	describe procedures used in <b>emergency situations</b>

## Range of Variables

**hazards** include: arc flash, arc blast, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation, open holes, confined space, fire, tripping hazards, overhead work, heights, SF<sub>6</sub> gas

**emergency situations** include: explosions, fire, hazardous product release

**designated substances** include: acrylonitrile, arsenic, asbestos, benzene, coke oven emissions, ethylene oxide, isocyanates, lead, mercury, silica, vinyl chloride

## A-1.02 Uses personal protective equipment (PPE) and safety equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-1.02.01P	identify <b>facility hazards</b> and regulations requiring use of <b>PPE</b> and <b>safety equipment</b>	<b>facility hazards</b> and regulations are determined according to facility visits and by performing a pre-job analysis
A-1.02.02P	select <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are selected according to tasks, facility hazards, OH&S and facility policies
A-1.02.03P	replace or tag and remove from service damaged or faulty <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are inspected for wear, damage or defect prior to use, and damaged or faulty <b>PPE</b> and <b>safety equipment</b> are replaced or tagged and removed from service
A-1.02.04P	ensure fit of <b>PPE</b>	<b>PPE</b> are adjusted to ensure fit according to manufacturers' specifications
A-1.02.05P	apply <b>safety regulations and standards</b>	<b>safety regulations and standards</b> are applied according to facility and AHJ requirements
A-1.02.06P	organize, clean and store <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are organized, cleaned and stored according to facility procedures and manufacturers' specifications
A-1.02.07P	recognize limitation of use of <b>PPE</b> and <b>safety equipment</b>	<b>PPE</b> and <b>safety equipment</b> are not used for other than their intended purposes according to manufacturers' limitation specifications

### Range of Variables

**facility hazards** include: heights, confined space, open excavation, live equipment, weather conditions, explosive gas and dust environments, oxygen deficient atmospheres, arc flash, arc blast

**PPE** includes: see Appendix B

**safety equipment** includes: see Appendix B

**safety regulations and standards** include: WHMIS, AHJ, CSA safety standards, facility safety policy, general/prime contractor policies

## Knowledge

	Learning Outcomes	Learning Objectives
A-1.02.01L	demonstrate knowledge of <b>PPE</b> and <b>safety equipment</b> , and their <b>applications</b> and limitations	identify types of <b>PPE</b> and <b>safety equipment</b> , and describe their <b>applications</b> and limitations
A-1.02.02L	demonstrate knowledge of regulatory requirements pertaining to <b>PPE</b> and <b>safety equipment</b>	identify and interpret regulatory requirements and responsibilities
A-1.02.03L	demonstrate knowledge of procedures to use, maintain and store <b>PPE</b> and <b>safety equipment</b>	describe procedures to use <b>PPE</b> and <b>safety equipment</b>
		describe procedures to maintain and store <b>PPE</b> and <b>safety equipment</b>

### Range of Variables

**PPE** includes: see Appendix B

**safety equipment** includes: see Appendix B

**applications** include: hazardous locations, height, confined space

### A-1.03 Performs lock-out and tag-out procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
A-1.03.01P	coordinate lock-out and tag-out requirements	lock-out and tag-out requirements are coordinated with applicable trades, and according to facility policy and sequence of events
A-1.03.02P	identify circuit for lock-out and tag-out, and other equipment that may present a hazard	circuit isolation point(s) and voltage are identified according to panel schedules, drawings, single-line diagrams, cable and equipment tags and other energy sources, and hazards are identified and secured
A-1.03.03P	select PPE and <b>approved device</b>	PPE and <b>approved device</b> is selected to match equipment and to ensure lock-out and tag-out
A-1.03.04P	identify potential <b>energy</b> source	potential <b>energy</b> source is identified to de-energize and lock-out equipment, and isolate circuit

A-1.03.05P	test for zero energy state	system is tested for zero energy state using <b>testing equipment</b>
A-1.03.06P	verify lock-out and tag-out	lock-out and tag-out is verified by performing a post-operational test to determine zero energy state according to OH&S and facility policies

### Range of Variables

**approved devices** include: breaker lock, multi-lock, lock box, lock tag, arc flash protection equipment

**energy** includes: electrical, mechanical, hydraulic, pneumatic, chemical, radiation, thermal, compressed air energy sources, energy stored in springs, potential energy from suspended parts (gravity)

**testing equipment** includes: permanently mounted absence of voltage tester, voltmeters, temporary protective ground equipment, high-voltage testers, pressure gauges, voltage sticks (hot sticks)

Knowledge		
	Learning Outcomes	Learning Objectives
A-1.03.01L	demonstrate knowledge of lock-out and tag-out procedures and legislation governing minimum standards	describe lock-out and tag-out procedures  identify legislation governing minimum standards for lock-out and tag-out procedures
A-1.03.02L	demonstrate knowledge of safety checks of equipment	describe safety checks to be performed to ensure zero energy state
A-1.03.03L	demonstrate knowledge of voltage testing procedures	describe procedures for voltage testing  describe procedures to determine if <b>testing equipment</b> is matched to voltage and energy rating

### Range of Variables

**testing equipment** includes: permanently mounted absence of voltage tester, voltmeters, temporary protective ground equipment, high-voltage testers, pressure gauges, voltage sticks (hot sticks)

n

## A-1.04 Identifies environmental conditions

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-1.04.01P	recognize <i>environmental conditions</i> of facility location	<i>environmental conditions</i> of facility location are recognized through sensory inspection, and according to plans and facility specifications
A-1.04.02P	select equipment	equipment is selected according to <i>environmental conditions</i> , and manufacturers' specifications and codes
A-1.04.03P	select cabling and raceways	cabling and raceways are selected according to <i>environmental conditions</i> , and manufacturers' specifications and codes

### Range of Variables

*environmental conditions* include: wet, dusty, icy, corrosive, hot and cold temperatures, wind, UV

### Knowledge

	Learning Outcomes	Learning Objectives
A-1.04.01L	demonstrate knowledge of <i>environmental conditions</i> and installation procedures	identify types of <i>environmental conditions</i>
		describe safe work procedures
		identify equipment designed for installation and operation in varying <i>environmental conditions</i>
		identify and describe wiring procedures and procedures in areas with varying <i>environmental conditions</i>

### Range of Variables

*environmental conditions* include: wet, dusty, icy, corrosive, hot and cold temperatures, wind, UV

## Task A-2 Uses tools and equipment

### Task Descriptor

Industrial electricians must be able to select, use and maintain tools and equipment in a safe and effective manner relevant to the task being performed.

#### A-2.01 Uses common and specialty tools and equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-2.01.01P	organize and store <b>tools, equipment</b> and <b>components</b>	<b>tools, equipment</b> and <b>components</b> are organized and stored in designated cases and areas according to facility and location requirements
A-2.01.02P	clean, lubricate and adjust <b>tools and equipment</b>	<b>tools and equipment</b> are cleaned, lubricated, adjusted and maintained according to manufacturers' specifications
A-2.01.03P	ensure calibration of measuring equipment	measuring equipment is calibrated according to manufacturers' specifications and facility policy
A-2.01.04P	identify worn, damaged and defective <b>tools, equipment</b> and <b>components</b>	worn, damaged and defective <b>tools, equipment</b> and <b>components</b> are tagged and replaced or repaired according to manufacturers' specifications
A-2.01.05P	change tool <b>accessories</b>	tool <b>accessories</b> are changed according to job requirements and manufacturers' specifications
A-2.01.06P	identify hazards associated with <b>tools and equipment</b>	hazards associated with <b>tools and equipment</b> are identified and PPE and safety equipment are used according to location, environment and application

### Range of Variables

**tools and equipment** include: standard hand tools, power tools and equipment, powder actuated tools, specialty tools and equipment, measuring instruments, test equipment

**components** include: batteries (primary and rechargeable), cords, attachment plugs

**accessories** include: threading dies, batteries, bending shoes, chucks, tool bits



## Knowledge

	Learning Outcomes	Learning Objectives
A-2.01.01L	demonstrate knowledge of <b>tools and equipment</b> , and their characteristics and applications	identify types of <b>tools and equipment</b> , and describe their characteristics and applications
A-2.01.02L	demonstrate knowledge of procedures to inspect, maintain and operate <b>tools and equipment</b>	describe procedures to inspect and maintain <b>tools and equipment</b>
		describe procedures to operate <b>tools and equipment</b>
A-2.01.03L	demonstrate knowledge of limitations and ratings of electrical measuring equipment	identify measuring equipment for various ratings and describe their limitations
		identify categories of electrical measuring equipment
A-2.01.04L	demonstrate knowledge of certification requirements to operate powder-actuated tools	describe certification requirements to operate powder-actuated tools

### Range of Variables

**tools and equipment** include: standard hand tools, power tools and equipment, powder actuated tools, specialty tools and equipment, measuring instruments, test equipment

## A-2.02 Uses access equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
A-2.02.01P	identify traffic areas and <b>potential hazards</b>	traffic areas and <b>potential hazards</b> are identified according to location requirements
A-2.02.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and <b>potential hazards</b>
A-2.02.03P	select <b>access equipment</b>	<b>access equipment</b> is selected according to their limitations and task at hand
A-2.02.04P	set up and secure step ladders and extension ladders	ladders are set up and used according to manufacturers' recommendations and AHJ requirements
A-2.02.05P	inspect for worn, damaged and defective <b>access equipment</b>	<b>access equipment</b> is visually and mechanically inspected for wear, <b>damage</b> and defects

A-2.02.06P	report, tag and decommission worn, damaged or defective <b>access equipment</b>	worn, damaged and defective <b>access equipment</b> is reported, tagged and removed from service
A-2.02.07P	organize and store <b>access equipment</b>	<b>access equipment</b> is organized and stored according to manufacturers' specifications and location requirements
A-2.02.08P	work from approved and certified <b>access equipment</b>	<b>access equipment</b> is certified and approved for job task
A-2.02.09P	complete approved training to operate <b>access equipment</b>	operator has completed approved training according to AHJ requirements
A-2.02.10P	perform <b>standard maintenance</b>	<b>standard maintenance</b> is performed according to manufacturers' specifications

## Range of Variables

**potential hazards** include: overhead hazards, ladder footing and stability, confined spaces, open trenches

**access equipment** includes: ladders, scissor-lifts, scaffoldings, articulating booms, fall protection (fall arrest and fall restraint), bucket truck

**damage** includes: broken ladder, leaking oil, missing or distorted safety catches, out-of-line safety chains and gates

**standard maintenance** includes: checking and filling fluid levels, checking and charging batteries, checking tires

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.02.01L	demonstrate knowledge of <b>access equipment</b> , their characteristics and applications	identify types of <b>access equipment</b> , and describe their characteristics and applications
A-2.02.02L	demonstrate knowledge of <b>regulatory requirements</b> pertaining to use, erection and dismantling of <b>access equipment</b>	identify hazards and describe safe work practices pertaining to <b>access equipment</b> identify and interpret <b>regulatory requirements</b> and responsibilities pertaining to use, erection and dismantling of <b>access equipment</b>
A-2.02.03L	demonstrate knowledge of procedures to erect and dismantle <b>access equipment</b>	identify certification for use of <b>access equipment</b> describe procedures to erect and dismantle ladders and scaffolding
A-2.02.04L	demonstrate knowledge of procedures to inspect, maintain and store <b>access equipment</b>	describe procedures to inspect, maintain and store <b>access equipment</b>

## Range of Variables

**access equipment** includes: ladders, scissor-lifts, scaffoldings, articulating booms and fall protection (fall arrest and fall restraint), bucket truck

**regulatory requirements** include: inspection documentation, training, certification

### A-2.03 Uses rigging, hoisting and lifting equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-2.03.01P	identify traffic areas and <b>potential hazards</b>	traffic areas and <b>potential hazards</b> are identified according to location requirements
A-2.03.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and <b>potential hazards</b>
A-2.03.03P	select rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is selected according to their lifting limitation, capacity, setting, task at hand, and engineering and AHJ requirements
A-2.03.04P	secure rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is secured according to manufacturers' and AHJ requirements
A-2.03.05P	use and interpret hand and audible signals	hand and audible signals are used to direct load to intended position
A-2.03.06P	inspect for worn, damaged and defective rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is visually and mechanically inspected for wear, <b>damages</b> and defects
A-2.03.07P	report, tag and decommission, damaged and defective rigging, hoisting and lifting equipment	damaged and defective rigging, hoisting and lifting equipment is reported, tagged and removed from service
A-2.03.08P	secure load for application	load is secured according to engineer and manufacturers' specifications, AHJ requirements and location policy
A-2.03.09P	clean, lubricate and store rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is cleaned, lubricated and stored according to location procedures and manufacturers' specifications
A-2.03.10P	move load to final position	load is moved to final position according to drawings and specifications

## Range of Variables

**potential hazards** include: overhead hazards, overhead power hazards, dropped loads, damaged rigging hardware, congested specific location in facility, confined spaces, open trenches, uneven surfaces, weather conditions

**damages** include: worn slings, worn shackles, missing or distorted safety catches, frayed ropes and slings, oil leaks

Knowledge		
	Learning Outcomes	Learning Objectives
A-2.03.01L	demonstrate knowledge of hoisting, lifting and rigging equipment, their applications, limitations and procedures for use	identify types of rigging equipment and accessories, and describe their applications, limitations and procedures for use
		identify types of hoisting and lifting equipment and accessories, and describe their applications, limitations and procedures for use
		identify <b>potential hazards</b> , and describe safe work practices pertaining to hoisting, lifting and rigging equipment
		describe procedures to inspect, maintain and store hoisting, lifting and rigging equipment
A-2.03.02L	demonstrate knowledge of <b>regulatory requirements</b> pertaining to hoisting, lifting and rigging equipment	identify and interpret codes and regulations pertaining to hoisting, lifting and rigging equipment
A-2.03.03L	demonstrate knowledge of basic hoisting and lifting operations	identify types of knots, hitches, splices and bends, and describe their applications and procedures to tie them
		describe <b>considerations</b> when rigging material or equipment for lifting
		identify and describe <b>procedures to communicate</b> during hoisting, lifting and rigging operations

## Range of Variables

**potential hazards** include: overhead hazards, overhead power hazards, dropped loads, damaged rigging hardware, congested specific location in facility, confined spaces, open trenches, uneven surfaces, weather conditions

**regulatory requirements** include: inspection documentation, training, certification

**considerations** include: load characteristics, working load limit (WLL), equipment and accessories, environmental factors, anchor points, sling angles

**procedures to communicate** include: hand signals, telephone or radio communications, audible/visual

## Task A-3 Organizes work

### Task Descriptor

Industrial electricians plan and organize projects, tasks and work orders in order to safely and efficiently use material, labour, tools and equipment. They interpret drawings, plans and specifications to identify required resources. Prior to starting, and for the project duration, they must plan their tasks, identify environmental conditions, identify hazardous locations, prepare the specific location in facility and organize the materials and supplies needed. Industrial electricians must document their work, prepare as-built drawings, and operations and maintenance (O&M) manuals.

#### A-3.01 Interprets plans, drawings and specifications

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-3.01.01P	identify symbols and <b>scaling</b>	symbols and <b>scaling</b> on drawings are identified from legends, notes and specifications
A-3.01.02P	determine location of equipment and devices	location of equipment and devices is determined by extracting from or making measurements using <b>scaling</b> from drawings
A-3.01.03P	locate and cross-reference information on plans, drawings, specifications and contract documents	installation information is obtained by interpreting plans, drawings, specifications and contract documents
A-3.01.04P	determine if plans, <b>drawings, schematics and specifications</b> are current	plans, <b>drawings, schematics and specifications</b> are verified for existing installation

### Range of Variables

**drawings, schematics and specifications** include: civil/site, architectural, mechanical, structural, electrical, shop, sketches, as-builts, logic, single line

**scaling** includes: metric, imperial, custom

#### Knowledge

	Learning Outcomes	Learning Objectives
A-3.01.01L	demonstrate knowledge of <b>drawings, schematics and specifications</b> and their applications	identify types of <b>drawings, schematics and specifications</b> , and describe their applications
		identify documentation requirements for modifying drawings and specifications

		describe procedures to document changes made to equipment and wiring
A-3.01.02L	demonstrate knowledge of imperial and système international (SI) measurement systems	identify imperial and SI units of measurement used in trade documentation
		convert between SI and imperial units of measurement
A-3.01.03L	demonstrate knowledge of interpreting and extracting <b>information</b> from <b>drawings, schematics and specifications</b>	interpret and extract <b>information</b> from <b>drawings, schematics and specifications</b>

### Range of Variables

**drawings, schematics and specifications** include: civil/site, architectural, mechanical, structural, electrical, shop, sketches, as-builts, logic, single line

**information** includes: elevations, scales, legends, symbols and abbreviations, notes and specifications, addendums, Construction Specifications Canada (CSC) specifications, codes and standards

## A-3.02 Identifies hazardous installations

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-3.02.01P	identify <b>hazardous installations</b>	<b>hazardous installations</b> are identified according to division system of classification, area classification drawings and AHJ requirements
A-3.02.02P	identify wiring procedures in <b>hazardous installations</b>	wiring procedures in <b>hazardous installations</b> are selected according to AHJ, CSA and CEC requirements
A-3.02.03P	identify equipment used in <b>hazardous installations</b>	equipment used in <b>hazardous installations</b> is identified by reading equipment labels and product documentation
A-3.02.04P	identify installations for where sealing is required	seals are located according to AHJ, CSA and CEC requirements

### Range of Variables

**hazardous installations** may contain: explosive gas, explosive and combustible dust, combustible fibers and flyings

## Knowledge

	Learning Outcomes	Learning Objectives
A-3.02.01L	demonstrate knowledge of <b>hazardous installations</b>	identify types of <b>hazardous installations</b> and describe safe work procedures
		identify types of potentially hazardous materials present, and procedures to designate an area to be a <b>hazardous installation</b>
		identify equipment and fittings designed for installation and operation in <b>hazardous installations</b>
		<b>hazardous installations</b> are identified according to division system of classification
A-3.02.02L	demonstrate knowledge of <b>hazardous installations</b> wiring methods	identify and describe wiring methods in <b>hazardous installations</b>

### Range of Variables

**hazardous installations** may contain: explosive gas, explosive and combustible dust, combustible fibers and flyings

## A-3.03 Organizes materials and supplies

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
A-3.03.01P	identify and select <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are selected according to drawings, specifications, and CSA, WHMIS and CEC requirements
A-3.03.02P	locate, order and schedule delivery of <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are ordered and delivered according to <b>criteria</b>
A-3.03.03P	load, unload and store <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are loaded, unloaded and stored according to related <b>factors</b>
A-3.03.04P	identify required <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are identified by performing material take-off according to drawings and specifications
A-3.03.05P	coordinate receiving of <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are received according to established schedule

A-3.03.06P	verify shipments for quality and quantity of <b>materials</b> and <b>supplies</b>	<b>materials</b> and <b>supplies</b> are counted and compared to order, and are inspected for shipping damage
A-3.03.07P	perform inventory control	inventory is counted, documented and stored in secured area

### Range of Variables

**materials** include: wires and cables, luminaires, panelboards, starters and contactors, transformers, distribution equipment, fittings, raceways, support hardware, wire connectors, fasteners

**supplies** (consumables) include: pulling compounds, tape, thread compounds

**criteria** include: storage availability, shelf life, product availability, delivery and site schedules

**factors** include: installation sequence, job specifications, site conditions, SDS, type of material

### Knowledge

	Learning Outcomes	Learning Objectives
A-3.03.01L	demonstrate knowledge of procedures to plan and organize <b>materials</b> and <b>supplies</b>	identify <b>sources of information</b> relevant to organize <b>materials</b> and <b>supplies</b>  describe <b>considerations</b> to organize <b>materials</b> and <b>supplies</b>

### Range of Variables

**materials** include: wires and cables, luminaires, panelboards, starters and contactors, transformers, distribution equipment, fittings, raceways, support hardware, wire connectors, fasteners

**supplies** (consumables) include: pulling compounds, tape, thread compounds

**sources of information** include: drawings, specifications, location facility and manufacturers' requirements, SDS, SCADA, protection settings

**considerations** include: available space, schedule, storage location

## A-3.04 Plans project tasks and procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-3.04.01P	determine job requirements	job requirements are determined according to specific location in facility, schedule and <b>documentation</b>
A-3.04.02P	determine labour and equipment requirements	labour and equipment requirements are determined according to <b>job specifications</b>



A-3.04.03P	establish and maintain schedules	schedules are maintained according to <b>criteria</b>
A-3.04.04P	coordinate work with other trades	work is coordinated with other trades according to <b>requirements</b>
A-3.04.05P	draw and sketch layouts	layouts are determined according to installation task at hand

### Range of Variables

**documentation** includes: location log, manufacturers' specifications, drawings (civil/site, architectural, mechanical, structural, shop, electrical, single line), sketches, logic diagram, digital images, location facility and manufacturers' requirements

**job specifications** include: CEC, conductor sizes, load requirements, locations

**criteria** include: inclement weather, product availability, project progression, critical path, project management tools

**requirements** include: shutdown and installation sequencing, worker qualifications

Knowledge		
	Learning Outcomes	Learning Objectives
A-3.04.01L	demonstrate knowledge of procedures to plan and organize job tasks	identify <b>sources of information</b> relevant to planning job tasks and procedures
		describe <b>considerations</b> to plan and organize job tasks and procedures
		describe functions of project schedule tools

### Range of Variables

**sources of information** include: drawings, specifications, location facility and manufacturers' requirements

**considerations** include: available space, schedule/sequence, permits, hazards assessment, personnel, tools and equipment, materials and supplies, storage location

## A-3.05 Prepares specific location in facility

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-3.05.01P	perform pre-job assessment	pre-job assessment is performed according to specific location in facility
A-3.05.02P	identify traffic areas and potential and existing <b>hazards</b>	<b>hazards</b> are identified, reported and mitigated according to OH&S, facility policies, and visual inspection of specific location in facility
A-3.05.03P	participate in specific location in facility safety meetings	specific location in facility safety meetings addresses risks and dangers and how they will be controlled
A-3.05.04P	contain work zone	work zone is contained by installing barricades and signage according to job and AHJ requirements
A-3.05.05P	create openings and penetrations in building elements and equipment	openings and penetrations are created according to job and AHJ requirements
A-3.05.06P	ensure sufficient lighting and ventilation of work area	work area is ventilated and level of lighting is according to AHJ requirements
A-3.05.07P	ensure required materials and equipment are at location	materials and equipment are readily accessible for installation
A-3.05.08P	control workplace and storage access	workplace and storage access is controlled by gates, fences and barriers to limit access
A-3.05.09P	ensure surveys are completed and <b>locates</b> are marked-out	surveys are completed and <b>locates</b> are identified on the ground with paint and documented

### Range of Variables

**hazards** include: arc flashes, liquid spills (flammable, corrosive, toxic), electric energy, designated substance (asbestos, mercury, lead, silica), open holes, confined space, fire, tripping hazards, overhead work, hazardous locations, uneven ground, high traffic area, elevated work areas, moving and mobile rotating equipment (conveyor belts, forklifts, cranes, robotics)

**locates** include: underground services and utilities, concealed building elements

## Knowledge

	Learning Outcomes	Learning Objectives
A-3.05.01L	demonstrate knowledge of procedures to prepare specific location in facility	identify <b>sources of information</b> to prepare specific location in facility
		identify <b>potential hazards</b> to prepare specific location in facility
		describe <b>considerations</b> to prepare specific location in facility
A-3.05.02L	demonstrate knowledge of procedures to locate <b>elements</b>	identify types of surveying equipment used to locate <b>elements</b> in concrete walls and floors, slab on grade and direct buried
		describe safety requirements taken when x-ray surveying equipment is used

### Range of Variables

**sources of information** include: drawings, specifications, AHJ, company, client and manufacturer requirements

**potential hazards** include: confined spaces and open trenches, overhead hazards, uneven ground, high traffic area, elevated work areas

**considerations** include: available space, schedule/sequence, permits, hazards assessment, personnel, tools and equipment, materials and supplies, storage location

**elements** include: conduits, heating cables, pipes, reinforcement bar, post-tensioned cables, utility services

### A-3.06 Finalizes required documentation

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
A-3.06.01P	document alterations	alterations are documented by modifying plans, schematics and drawings to reflect changes and additions made to original application
A-3.06.02P	log data from various <b>sources</b> to assist with maintenance and replacement	paper and digital copies of setting and parameter files are saved to assist with maintenance and replacement
A-3.06.03P	communicate status of task, lockout and tagout to <b>personnel</b>	status of task, lockout and tagout are communicated to <b>personnel</b> according to facility policies

A-3.06.04P	compile maintenance manuals from installed equipment manufacturers' specifications	product data sheets for installed equipment are included in maintenance manuals
A-3.06.05P	submit final documentation, including <b>revisions</b> to facility manager	<b>revisions</b> and O&M manuals are submitted to facility manager according to job specifications

### Range of Variables

**sources** include: equipment parameters (VFD, circuit breakers, HMI, PLC, drawings, schematics, programs)

**personnel** include: other shift, supervisor, production staff

**revisions** include: as-builts, redline changes

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
A-3.06.01L	demonstrate knowledge of <b>documentation</b> , its purpose, application and use	describe and identify types of <b>documentation</b> developed from tasks
		describe procedures for finalizing <b>documentation</b>

### Range of Variables

**documentation** includes: meeting records, manufacturers' specifications, as-built drawings (civil/site, architectural, mechanical, structural, shop, electrical, single line), sketches, logic diagram

## Task A-4 Fabricates and installs support components

### Task Descriptor

Industrial electricians fabricate support structures to protect and support electrical equipment and components. They use various methods to secure equipment to structures in order to maintain a safe installation, and reduce hazards and unwanted movements. Seismic restraint systems are used as an additional support where required.

#### A-4.01 Fabricates support structures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-4.01.01P	select <b>tools and equipment</b>	<b>tools and equipment</b> are selected according to task
A-4.01.02P	evaluate equipment to determine support structure size, strength and weight	dimensions of support structure is determined according to equipment size requirements, drawings, and manufacturers' specifications
A-4.01.03P	draw sketch	sketch is drawn with dimensions and measurements of support structure and equipment
A-4.01.04P	determine <b>materials</b> for support structure	<b>materials</b> are selected according to job specifications and <b>factors</b>
A-4.01.05P	select and use <b>fasteners</b>	<b>fasteners</b> are selected according to job specifications and location conditions
A-4.01.06P	prepare <b>materials</b>	<b>materials</b> are cut to length and shape, holes are drilled to size and location according to sketch, and are painted and coated for corrosion protection
A-4.01.07P	assemble <b>materials</b> to create structure	structure is assembled according to sketch, and is straight, true and free of sharp protrusions

### Range of Variables

**tools and equipment** include: measuring equipment, saws, drills, clamps, welding equipment

**materials** include: wood, steel, aluminum

**factors** include: environment, strength and durability ratings, cost, vibration

**fasteners** include: screws, straps, inserts, nuts, bolts, anchors, wedge clamps, seismic restraints

## Knowledge

	Learning Outcomes	Learning Objectives
A-4.01.01L	demonstrate knowledge of interpreting, creating and extracting information from sketches, drawings and specifications	create, interpret and extract information from sketches, drawings and specifications
		identify support <b>materials</b> , their characteristics and application
		identify <b>fasteners</b> , their characteristics and application
A-4.01.02L	demonstrate knowledge of procedures to fabricate support structures	identify <b>tools and equipment</b> used to fabricate support structures, and describe their applications and procedures for use
		describe procedures to fabricate support structures

### Range of Variables

**materials** include: wood, steel, aluminum

**fasteners** include: screws, straps, inserts, nuts, bolts, anchors, wedge clamps, seismic restraints

**tools and equipment** include: measuring equipment, saws, drills, clamps, welding equipment

## A-4.02 Installs brackets, hangers and fasteners

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
A-4.02.01P	select <b>brackets, hangers</b> and <b>fasteners</b>	<b>brackets, hangers</b> and <b>fasteners</b> are selected according to job specifications and intended purposes
A-4.02.02P	select tools and equipment	tools and equipment are selected according to task
A-4.02.03P	determine installation location	installation location is determined and <b>obstructions</b> are avoided
A-4.02.04P	secure <b>brackets</b> and <b>hangers</b> to structure using <b>fasteners</b>	<b>brackets</b> and <b>hangers</b> are secured using <b>fasteners</b> , and are level, square, following building lines when possible, according to intended purposes, job and manufacturer specifications, and facility and CEC requirements

## Range of Variables

**brackets** include: channel, angle brackets, T brackets, L brackets, floor brackets, ceiling brackets

**hangers** include: trapezes, pipe clamps, beam clamps

**fasteners** include: spring nuts, bolts, screws, concrete anchors

**obstructions** include: duct work, plumbing pipes, structural building elements, equipment

Knowledge		
	Learning Outcomes	Learning Objectives
A-4.02.01L	demonstrate knowledge of <b>brackets</b> , <b>hangers</b> and <b>fasteners</b> , their characteristics and applications	identify types of <b>brackets</b> , <b>hangers</b> and <b>fasteners</b> , and describe their characteristics and applications
		identify <b>building materials</b> , their characteristics and applications
A-4.02.02L	demonstrate knowledge of procedures to install <b>brackets</b> , <b>hangers</b> and <b>fasteners</b>	identify tools and equipment used to install <b>brackets</b> , <b>hangers</b> and <b>fasteners</b> , and describe their applications and procedures for use
		describe measurement and layout techniques to ensure <b>brackets</b> , <b>hangers</b> and <b>fasteners</b> are positioned and mounted
		describe procedures for securing <b>brackets</b> , <b>hangers</b> and <b>fasteners</b> to structure

## Range of Variables

**brackets** include: channel, angle brackets, T brackets, L brackets, floor brackets, ceiling brackets

**hangers** include: trapezes, pipe clamps, beam clamps

**fasteners** include: spring nuts, bolts, screws, concrete anchors

**building materials** include: steel, concrete, brick, block, wood

## A-4.03 Installs seismic restraint systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-4.03.01P	select and fabricate <b>seismic restraint systems</b>	<b>seismic restraint systems</b> are selected and fabricated according to job specifications and jurisdictional regulations
A-4.03.02P	select tools and equipment	tools and equipment are selected according to task
A-4.03.03P	determine installation location	installation location is determined and <b>obstructions</b> are avoided
A-4.03.04P	position, mount and secure <b>seismic restraint systems</b> to structure	<b>seismic restraint systems</b> are positioned, mounted and secured according to structure location, job specifications and jurisdictional regulations

### Range of Variables

**seismic restraint systems** include: chains, cables, thimbles, rods, wire rope clamps, shock mounts  
**obstructions** include: duct work, plumbing pipes, structural building elements, equipment

### Knowledge

	Learning Outcomes	Learning Objectives
A-4.03.01L	demonstrate knowledge of <b>seismic restraint systems</b> , their characteristics and applications	identify types of <b>seismic restraint systems</b> , their characteristics and limitations
		identify materials to be installed
A-4.03.02L	demonstrate knowledge of procedures for mounting and securing <b>seismic restraint systems</b> to structure	identify tools and equipment used to mount and secure <b>seismic restraint systems</b> to structure, and describe their applications and procedures for use
		describe procedures for mounting and securing <b>seismic restraint systems</b> to structure

### Range of Variables

**seismic restraint systems** include: chains, cables, thimbles, rods, wire rope clamps, shock mounts



## Task A-5 Commissions and decommissions electrical systems

### Task Descriptor

Industrial electricians commission electrical systems to ensure safe and intended operation. Commissioning of electrical systems may require liaison with clients, equipment manufacturers, AHJ's, and health and safety committees. Industrial electricians also shut down and start up systems to perform maintenance or to replace defective equipment. They decommission systems to prepare them for removal and dispose of components according to codes and standards.

#### A-5.01 Commissions systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-5.01.01P	isolate <b>potential</b> from equipment and component connected to system	equipment is de-energized using lockout and tagout procedures
A-5.01.02P	verify that safety and shipping material has been removed from equipment and check for tools and loose hardware prior to startup	shipping material, industrial debris and tools are removed from equipment and loose equipment hardware is secured prior to startup
A-5.01.03P	check documentation and nameplate data for operational parameters	operational parameters are set or adjusted according to manufacturers' and design specifications
A-5.01.04P	select tools and equipment	tools and equipment are selected according to task
A-5.01.05P	verify busbar connections and torquing of bolts	busbars are torqued according to manufacturers' specifications
A-5.01.06P	identify and collaborate with other trades involved in commissioning of system	other trades involved in commissioning of system are identified and informed of system status
A-5.01.07P	visually inspect system for <b>problems</b>	<b>problems</b> are identified according to visual inspection and corrected
A-5.01.08P	confirm <b>system components</b> are functional	<b>system components</b> are operating according to their intended purpose
A-5.01.09P	test system	system is tested according to manufacturers' and design specifications
A-5.01.10P	perform <b>operational checks</b>	results of <b>operational checks</b> are documented

A-5.01.11P	adjust components to achieve desired operation	components are adjusted so that equipment operates as an integrated system
A-5.01.12P	complete <b>documentation</b>	required <b>documentation</b> is completed and includes <b>system components</b> tested, test results and changes that were completed

## Range of Variables

**potential** includes: electrical, kinetic, mechanical, ionizing radiation, thermal, hydraulic, pneumatic, gravity

**problems** include: wrong direction of rotation, out of specification rotation speed, alarm tripping, equipment malfunction, foreign material left in equipment, voltage regulation, current regulation, temperature regulation, direction of laser and ultrasonic beams, status indicators

**system components** include: detection systems, status and alarm systems, inputs, outputs

**operational checks** include: current, winding temperature, phase rotation, voltage, protection settings, drives parameters, Proportional, Integral, Derivative (PID) loop tuning, safety circuits

**documentation** includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications

## Knowledge

	Learning Outcomes	Learning Objectives
A-5.01.01L	demonstrate knowledge of purpose of commissioning	identify <b>hazards</b> and describe safe work practices pertaining to commissioning systems or equipment
		identify purpose of commissioning and types of systems and equipment requiring them
		identify and interpret <b>information sources</b> and <b>documentation</b> pertaining to commissioning of systems or equipment
		identify <b>diagnostic and test equipment</b> for purpose of commissioning systems
A-5.01.02L	demonstrate knowledge of commissioning procedures	identify tools and equipment used to commission systems, and describe their applications and procedures for use
		describe commissioning procedures

## Range of Variables

**hazards** include: arc flash, arc blast, electric shocks, potential, moving, mobile and rotating equipment (conveyor belts, forklifts, cranes, robotics)

**information sources** include: O&M manuals, single line diagrams, schematics, panel schedules, CSA safety standards

**documentation** includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications

**diagnostic and test equipment** includes: permanently mounted absence of voltage tester, multimeters, voltage testers, ammeters, oscilloscopes, power quality analyzers, hi-pot testers, thermographic imaging devices, phase/motor rotation meters, insulation resistance testers, ground loop testers, acoustic level sensor, protective relay testers, high-voltage equipment testers

### A-5.02 Performs shutdown and startup procedures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-5.02.01P	follow specifications sequence for shutdown	system is de-energized according to job specifications, type of system and manufacturers' specifications
A-5.02.02P	identify equipment that needs to be de-energized	<b>system equipment</b> to be de-energized is identified and its <b>energy sources</b> are locked out and tagged out
A-5.02.03P	select tools and equipment	tools and equipment are selected according to task
A-5.02.04P	install temporary protective ground equipment on shutdown, and remove on startup	temporary protective ground equipment is installed and removed according to AHJ, CSA, CEC and job requirements, and facility policies
A-5.02.05P	test cables and conductors	cables and conductors are tested for ground faults and phase identification with an insulation resistance tester and continuity tester
A-5.02.06P	verify that drawings match field wiring	drawings are matched according to design parameters
A-5.02.07P	verify <b>connected components</b> operate	operation of <b>connected components</b> matches function
A-5.02.08P	verify connections and terminations, and torquing of bolts	connections and terminations are verified, and bolts torqued according to manufacturers' specifications

A-5.02.09P	inspect and remove tools, temporary grounds, jumpers, debris, gravity pins, blocking and latching devices	tools, temporary grounds, jumpers, debris, gravity pins, blocking and latching devices are inspected and removed according to commissioning documentation, CSA requirements, and facility policies and procedures
A-5.02.10P	follow specifications sequence for startup	system is energized according to job specifications, type of system and manufacturers' specifications
A-5.02.11P	identify <b>system equipment</b> that needs to be energized	<b>system equipment</b> to be energized is identified and its source of supply is verified by <b>documentation</b>
A-5.02.12P	notify required personnel of shutdown and startup procedures	personnel is notified and cleared from area prior to shutdown and startup procedures

## Range of Variables

**system equipment** includes: control equipment, power distribution equipment

**energy sources** include: electrical, kinetic, mechanical, ionizing radiation, thermal, hydraulic, pneumatic, gravity, emergency and alternate power sources

**documentation** includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications, standard operating procedures

**connected components** include: limit switches, I/O cards, safety devices, push buttons, pressure and temperature sensors, printed circuit boards

## Knowledge

Learning Outcomes		Learning Objectives
A-5.02.01L	demonstrate knowledge of shutdown and startup procedures and their purpose	identify <b>hazards</b> , and describe safe work practices pertaining to shutting down and starting up systems or equipment
		describe purpose of shutting down and starting up, and types of systems and equipment requiring it
		identify and interpret <b>information sources</b> and documentation pertaining to shutting down and starting up of systems or equipment
A-5.02.02L	demonstrate knowledge of shutdown and startup procedures for systems or equipment	identify tools and equipment used for shutdown and startup procedures for systems or equipment, and describe their applications and procedures for use
		describe shutdown and startup procedures for various types of systems and equipment

## Range of Variables

**hazards** include: arc flash, arc blast, electric shocks, uncontrolled release of energy, moving, mobile and rotating equipment (conveyor belts, forklifts, cranes, robotics)

**information sources** include: O&M manuals, single line diagrams, schematics, panel schedules, CEC requirements, CSA standards, AHJ, manufacturers' specifications, facility policies and procedures

### A-5.03 Decommissions systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-5.03.01P	check documentation for inter-related systems	inter-related systems are analyzed and affected systems remain functional and free from hazards
A-5.03.02P	collaborate with other trades to ensure equipment is isolated from all energy sources	other trades are informed of disconnected services and all hazards are removed; equipment is placed in zero energy state
A-5.03.03P	identify and remove <b>equipment feed</b> from distribution source	<b>equipment feed</b> is disconnected and removed from distribution source
A-5.03.04P	confirm system is de-energized	system is checked to confirm absence of all <b>energy sources</b>
A-5.03.05P	recycle <b>system components</b>	<b>system components</b> are recycled according to facility requirements
A-5.03.06P	dispose of <b>system components</b> and waste	<b>system components</b> and waste are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
A-5.03.07P	record changes to <b>facility documentation</b>	<b>facility documentation</b> is modified to reflect decommissioning changes

## Range of Variables

**equipment feed** includes: cable, conduit, conductors, disconnects, circuit breakers

**energy sources** include: electrical, kinetic, mechanical, ionizing radiation, thermal, hydraulic, pneumatic, gravity, emergency and alternate power sources

**system components** include: panels, lamps, ballasts, fixtures, cables, switch gear, transformers, capacitors, motors, breakers, disconnect switches, protective relays

**facility documentation** includes: O&M manuals, single line diagrams, schematics, panel schedules, as-built drawings, procedure manuals, equipment programming

## Knowledge

	Learning Outcomes	Learning Objectives
A-5.03.01L	demonstrate knowledge of decommissioning and its purpose	identify <b>hazards</b> and describe safe work practices pertaining to decommissioning systems or equipment identify <b>energy sources</b> used in system or equipment being decommissioned identify purpose of decommissioning and types of systems and equipment requiring them identify, interpret and modify <b>information sources</b> and <b>documentation</b> pertaining to decommissioning of systems or equipment
A-5.03.02L	demonstrate knowledge of decommissioning procedures	identify <b>diagnostic and test equipment</b> for purpose of decommissioning systems identify tools and equipment used to decommission systems or equipment, and describe their applications and procedures for use describe decommissioning procedures

### Range of Variables

**hazards** include: arc flash, arc blast, electric shocks, moving, mobile and rotating equipment (conveyor belts, forklifts, cranes, robotics)

**energy sources** include: electrical, kinetic, mechanical, ionizing radiation, thermal, hydraulic, pneumatic, gravity, emergency and alternate power sources

**information sources** include: O&M manuals, single line diagrams, schematics, panel schedules, CSA safety standards

**documentation** includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications

**diagnostic and test equipment** includes: multimeters, voltage testers, thermographic imaging devices, geiger counter

## Task A-6 Uses communication and mentoring techniques

### Task Descriptor

Learning in the trades is done primarily in the workplace with tradespeople passing on their skills and knowledge to apprentices, as well as sharing knowledge among themselves. Apprenticeship is, and always has been about mentoring – learning workplace skills and passing them on. Because of the importance of this to the trade, this task covers the activities related to communication in the workplace and mentoring skills.

#### A-6.01 Uses communication techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
A-6.01.01P	demonstrates communication practices with individuals or in a group	instructions and messages are interpreted by all parties involved in communication
A-6.01.02P	listen using <b>active listening</b> practices	<b>active listening</b> practices are utilized
A-6.01.03P	receive and respond to feedback on work	response to feedback indicates understanding and corrective measures are taken
A-6.01.04P	explain and provide feedback	explanation and feedback is provided and task is carried out as directed
A-6.01.05P	use questioning to improve communication	questions enhance understanding, on-the-job training and goal setting
A-6.01.06P	participate in safety and information meetings	safety and information meetings are attended, and information is relayed to workforce and applied

### Range of Variables

**active listening** includes: hearing, interpreting, reflecting, responding, paraphrasing

#### Knowledge

	Learning Outcomes	Learning Objectives
A-6.01.01L	demonstrate knowledge of trade terminology	define terminology used in trade
A-6.01.02L	demonstrate knowledge of effective communication practices	describe importance of using effective verbal and non-verbal communication with <b>people in the workplace</b> identify <b>sources of information</b> to effectively communicate

	identify communication and <b>learning styles</b>
	identify <b>personal responsibilities and attitudes</b> that contribute to on-the-job success
	identify communication that constitutes <b>harassment</b> and <b>discrimination</b>
	identify communication styles appropriate to different systems and applications of <b>electronic messages</b>

## Range of Variables

**people in the workplace** include: other tradespeople, colleagues, apprentices, supervisors, clients, AHJ, manufacturers, customers, public

**sources of information** include: regulations, codes, occupational health and safety requirements, AHJ requirements, prints, drawings, specifications, facility documentation

**learning styles** include: seeing it, hearing it, trying it

**personal responsibilities and attitudes** include: asking questions, working safely, accepting constructive feedback, time management and punctuality, respect for authority, good stewardship of materials, tools and property, efficient work practice

**harassment:** as defined by the Canadian and jurisdictional Human Rights Commissions

**discrimination:** as defined by the Canadian Human Rights Act and jurisdictional human rights laws

**electronic messages** include: email, text messages

## A-6.02 Uses mentoring techniques

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
A-6.02.01P	identify and communicate learning objective and point of lesson	apprentice or learner can explain objective and point of lesson
A-6.02.02P	link lesson to other lessons and job	lesson order and unplanned learning opportunities are defined
A-6.02.03P	demonstrates performance of a skill to an apprentice or learner	<b>steps required to demonstrate a skill</b> are performed
A-6.02.04P	set up conditions required for an apprentice or learner to practice a skill	<b>practice conditions</b> are set up so that skill can be practiced safely by apprentice or learner
A-6.02.05P	assess apprentice or learner's ability to perform tasks with increasing independence	performance of apprentice improves with practice to a point where skill can be done with little supervision



A-6.02.06P	give supportive and corrective feedback	apprentice or learner adopts best practice after having been given supportive or corrective feedback
A-6.02.07P	support apprentices or learners in pursuing technical training opportunities	technical training is completed within timeframe prescribed by apprenticeship authority
A-6.02.08P	support anti- <b>harassment</b> in workplace	workplace is <b>harassment</b> and <b>discrimination-free</b>
A-6.02.09P	assess apprentice or learner suitability to trade during probationary period	apprentice or learner is given feedback that helps them identify their own strengths and weaknesses and suitability for trade

## Range of Variables

**steps required to demonstrate a skill** include: understanding the who, what, where, when, why, and how, explaining, showing, giving encouragement, following up to ensure skill is performed correctly

**practice conditions** means: guided, limited independence, full independence

**harassment:** as defined by the Canadian and jurisdictional Human Rights Commissions

**discrimination:** as defined by the Canadian Human Rights Act and jurisdictional human rights laws

Knowledge		
	Learning Outcomes	Learning Objectives
A-6.02.01L	demonstrate knowledge of strategies for learning skills in workplace	describe importance of individual experience
		describe shared responsibilities for workplace learning
		determine one's own learning preferences and explain how these relate to learning new skills
		describe importance of different types of skills in workplace
		describe importance of <b>essential skills</b> in workplace
		identify different <b>learning styles</b>
		identify different <b>learning needs</b> and strategies to meet them
A-6.02.02L	demonstrate knowledge of strategies for <b>teaching skills</b>	identify different roles played by a workplace mentor
		describe <b>teaching skills</b>
		explain importance of identifying point of a lesson

	identify how to choose a good time to present a lesson
	explain importance of linking lessons
	identify components of skill (the context)
	describe considerations in setting up opportunities for skill practice
	explain importance of providing feedback
	identify techniques for giving effective feedback
	describe a skills assessment
	identify methods of assessing progress
	explain how to adjust a lesson to different situations

### Range of Variables

**essential skills** are: reading, writing, document use, oral communication, numeracy, thinking, working with others, digital technology, continuous learning

**learning styles** include: seeing it, hearing it, trying it

**learning needs** include: learning disabilities, learning preferences, language proficiency

**strategies to assist in learning a skill** include: understanding the basic principles of instruction, developing coaching skills, being mature and patient, providing feedback

**steps for teaching skills** include: identifying the point of the lesson, linking the lesson, demonstrating the skill, providing practice, giving feedback, assessing skills and progress

# Major Work Activity B

## Installs and maintains generating, transmission, distribution and service systems

### Task B-7 Installs and maintains utility and non-utility supply services and metering equipment

#### Task Descriptor

A utility supply service includes the consumer and supply authority, and a non-utility supply service includes energy management (sub-metering/non-billing). Service entrance equipment distributes the power for single-phase and three-phase electrical systems and equipment. Service equipment allows for the safe connection to the supply distribution systems for the utilization of electricity to meet the needs in buildings and structures.

Supply services can provide normal and temporary power. This equipment allows for the safe utilization of electricity.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

Industrial electricians maintain single-phase and three-phase consumer/supply services and metering equipment by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure the consumer/supply services and metering equipment are in good operating condition.

For the purpose of this standard, “maintain” includes inspections, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

#### **B-7.01** Installs utility and non-utility single-phase supply services and metering equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
B-7.01.01P	select tools and equipment	tools and equipment are selected according to task

B-7.01.02P	determine <b>services</b> , and size and type of <b>service components</b> and <b>service conductors</b>	size and type of <b>service components</b> and <b>service conductors</b> are selected according to calculated load, facility and CEC requirements, and location conditions
B-7.01.03P	determine layout, vertical clearance, working space, and location of <b>service components</b>	layout allows for <b>service components</b> to be mounted according to <b>supply authority</b> standards and CEC requirements
B-7.01.04P	determine trench size and minimum cover requirements	trench size and cover allows for installation of direct burial cables and underground raceways, and are constructed according to <b>supply authority</b> standards and CEC requirements
B-7.01.05P	protect <b>service components</b> for single-phase service	<b>service components</b> are protected from environmental and mechanical damage, and from public access according to <b>supply authority</b> standards and CEC requirements
B-7.01.06P	mount and secure <b>service components</b>	<b>service components</b> are securely mounted using <b>fasteners</b> designed to attach to support structure according to <b>supply authority</b> standards and CEC requirements
B-7.01.07P	install <b>service conductors</b>	<b>service conductors</b> are installed without damage to insulation, without stress and neutral conductor is identified
B-7.01.08P	terminate <b>service conductors</b>	insulation is removed, antioxidant is applied and <b>service conductors</b> are tightened and secured according to manufacturers' specifications and CEC requirements
B-7.01.09P	conduct tests of <b>service components, service conductors</b> and <b>metering equipment</b>	<b>service components, service conductors</b> and <b>metering equipment</b> are tested, connected and function according to application requirements and to facilitate commissioning
B-7.01.10P	identify service information on panels and <b>metering equipment</b>	branch circuits and main overcurrent protection devices are labelled on panel directory and <b>metering equipment</b>
B-7.01.11P	bond non-current carrying metallic <b>service components</b>	non-current carrying metallic <b>service components</b> are bonded according to <b>supply authority</b> standard and CEC requirements
B-7.01.12P	ground neutral conductors	neutral conductor is grounded according to <b>supply authority</b> standards and CEC requirements

B-7.01.13P	bond <b>non-electrical metallic piping and structures</b>	<b>non-electrical metallic piping and structures</b> are bonded according to <b>supply authority</b> standards, and AHJ, CSA and CEC requirements
B-7.01.14P	remove and dispose of or recycle unserviceable <b>service components</b> and <b>service conductors</b>	unserviceable <b>service components</b> and <b>service conductors</b> are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
B-7.01.15P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**services** include: overhead, underground, temporary

**service components** include: supports, enclosures, raceways, conduit, meter sockets, panels, service entrance equipment, service mast, point of attachment

**service conductors** include: wire, cables, conductors

**supply authority** includes: local utility, electrical inspectors

**fasteners** include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

**metering equipment** includes: meter sockets, current transformers (CTs), voltage transformers (VTs), enclosures, meter mounting equipment, associated secondary wiring

**non-electrical metallic piping and structures** include: gas lines, water pipes, metallic building components

**documentation** includes: drawings, disposal documents, work orders, permits, supply authority documentation, terminal identification

Knowledge		
	Learning Outcomes	Learning Objectives
B-7.01.01L	demonstrate knowledge of <b>single-phase services</b> and their applications	interpret codes and regulations pertaining to <b>single-phase services</b>
		interpret information pertaining to <b>single-phase services</b> found on drawings and specifications
		interpret <b>supply authority</b> single-phase standards
		identify types of <b>single-phase services</b> , and describe their characteristics and applications
		identify <b>service components</b> , <b>service conductors</b> and <b>fasteners</b> , and describe their purpose and applications
		identify considerations and requirements for selecting type of <b>single-phase services</b> , <b>service components</b> and <b>service conductors</b>

B-7.01.02L	demonstrate knowledge of procedures to install <b>single-phase service</b>	identify tools and equipment used to install <b>single-phase service</b> , and describe their applications and procedures for use
		identify sources of information and documentation required for installation of <b>single-phase services</b>
		identify and describe procedures to install <b>single-phase services, service components, service conductors</b> and <b>metering equipment</b>
		identify and describe procedures to connect <b>service conductors</b>
		identify procedures to ground and bond <b>single-phase services</b>
B-7.01.03L	demonstrate knowledge of demand load calculations for <b>single-phase service</b>	describe procedures to calculate demand load
		describe demand load for <b>single-phase service</b>
B-7.01.04L	demonstrate knowledge of theory of single-phase systems	describe theory of single-phase three-wire system
		describe single-phase circuit fundamentals

### Range of Variables

**single-phase services** include: temporary service, overhead, underground, single and multiple metering

**service components** include: supports, enclosures, raceways, conduit, panels, service mast, point of attachment

**service conductors** include: wire, cables, conductors, bus ducts

**fasteners** include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

**metering equipment** includes: meter sockets, CTs, PTs, enclosures, meter mounting equipment, associated secondary wiring

**B-7.02****Maintains utility and non utility single-phase supply services and metering equipment**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

**Skills**

Performance Criteria		Evidence of Attainment
B-7.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-7.02.02P	select tools and equipment	tools and equipment are selected according to task
B-7.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-7.02.04P	determine course of action	course of action is determined according to type of malfunction and availability of replacement parts
B-7.02.05P	repair malfunctioning components	repaired components are operational according to as-built specifications
B-7.02.06P	select replacement components	original equipment manufacturer (OEM) or equivalent replacement components are selected
B-7.02.07P	install replacement components	OEM or equivalent replacement components are installed according to as-built or equivalent specifications with minimal disruptions
B-7.02.08P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' recommendations
B-7.02.09P	create maintenance schedule	maintenance schedule is created according to maintenance documentation and requirements
B-7.02.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-7.02.11P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> and results documented

B-7.02.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-7.02.13P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, TDR (time domain reflectometer), non-contact infrared sensor

Knowledge		
	Learning Outcomes	Learning Objectives
B-7.02.01L	demonstrate theoretical knowledge of single-phase systems	describe theory of single-phase, two- and three-wire systems
		describe single-phase circuit fundamentals
B-7.02.02L	demonstrate knowledge of procedures to maintain single-phase services and their components	identify tools and equipment used to maintain single-phase services and their components, and describe their applications and procedures for use
		describe procedures to maintain single-phase services and their components



**B-7.03****Installs utility and non-utility three-phase supply services and metering equipment**

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

**Skills**

	Performance Criteria	Evidence of Attainment
B-7.03.01P	select tools and equipment	tools and equipment are selected according to task
B-7.03.02P	determine <b>services</b> , size and type of <b>service components</b> and <b>service conductors</b> , and <b>metering equipment</b>	<b>services</b> , size and type of <b>service components</b> and <b>service conductors</b> and <b>metering equipment</b> are selected according to calculated load, facility and CEC requirements, and location conditions
B-7.03.03P	determine layout, clearance and location of <b>service components</b>	layout allows for <b>service components</b> to be mounted according to <b>supply authority</b> standards and CEC requirements
B-7.03.04P	determine trench size and minimum cover requirements	trench size and cover allows for installation of direct burial cables and underground raceways, and are constructed according to <b>supply authority</b> standards and CEC requirements
B-7.03.05P	protect <b>service components</b> for three-phase service	<b>service components</b> for three-phase service are protected from environmental and mechanical damage, and from public access according to <b>supply authority</b> standards and CEC requirements
B-7.03.06P	mount and secure <b>service components</b>	<b>service components</b> are securely mounted using <b>fasteners</b> designed to attach to support structure according to <b>supply authority</b> standards and CEC requirements
B-7.03.07P	install <b>service conductors</b>	<b>service conductors</b> are installed without damage to insulation, without stress, and neutral and three-phase conductors are colour-coded
B-7.03.08P	terminate <b>service conductors</b>	insulation is removed, antioxidant is applied and <b>service conductors</b> are tightened and secured according to manufacturers' specifications and CEC requirements

B-7.03.09P	conduct tests of <b>service components, service conductors</b> and <b>metering equipment</b>	<b>service components, service conductors</b> and <b>metering equipment</b> are tested, connected and function according to application requirements and to facilitate commissioning
B-7.03.10P	identify service information on <b>metering equipment</b> , main disconnect and panels	branch circuits and main overcurrent protection devices are identified on <b>metering equipment</b> , main disconnect and panels
B-7.03.11P	bond non-current carrying metallic <b>service components</b>	non-current carrying metallic <b>service components</b> are bonded according to <b>supply authority</b> standards and CEC requirements
B-7.03.12P	ground neutral conductor	neutral conductor is grounded according to <b>supply authority</b> standards and CEC requirements
B-7.03.13P	bond <b>non-electrical metallic piping and structures</b>	<b>non-electrical metallic piping and structures</b> are bonded according to <b>supply authority</b> standards, and AHJ, CSA and CEC requirements
B-7.03.14P	remove and dispose of or recycle unserviceable <b>service components</b> and <b>service conductors</b>	unserviceable <b>service components</b> and <b>service conductors</b> are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
B-7.03.15P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**services** include: overhead, underground, temporary

**service components** include: supports, enclosures, raceways, conduit, panels, switchgear, service entrance equipment, service mast, point of attachment

**service conductors** include: wire, cables, conductors

**supply authority** includes: local supply authority, electrical inspectors

**fasteners** include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

**metering equipment** includes: meter sockets, CTs, VTs, enclosures, meter mounting equipment, associated secondary wiring

**non-electrical metallic piping and structures** include: gas lines, water pipes, metallic building components

**documentation** includes: drawings, disposal documents, work orders, permits, supply authority documentation, terminal identification

## Knowledge

Learning Outcomes	Learning Objectives	
B-7.03.01L	demonstrate knowledge of <b>three-phase services</b> , their characteristics and applications	identify types of <b>three-phase services</b> , and describe their characteristics and applications
		interpret information pertaining to <b>three-phase services</b> found on drawings and specifications
		interpret codes and regulations pertaining to <b>three-phase services</b>
		identify <b>service components, service conductors</b> and <b>fasteners</b> , and describe their purpose and applications
		interpret supply authority three-phase standards
		identify considerations and requirements for selecting <b>three-phase services, service components, service conductors</b> and <b>metering equipment</b>
		identify ground fault and ground detection type protection systems, and describe their characteristics and applications
B-7.03.02L	demonstrate knowledge of procedures to install <b>three-phase service, service components</b> and <b>service conductors</b>	identify tools and equipment used to install <b>three-phase services, service components</b> and <b>service conductors</b> , and describe their applications and procedures for use
		identify sources of information and documentation required for installation of <b>three-phase services</b>
		identify and describe procedures to install <b>three-phase services, service components</b> and <b>service conductors</b>
		identify and describe procedures to connect <b>service conductors</b>
		identify procedures to ground and bond <b>three-phase services</b>
B-7.03.03L	demonstrate knowledge of demand load calculations for <b>three-phase services</b>	identify procedures to calculate demand load
		calculate demand load for <b>three-phase services</b>
B-7.03.04L	demonstrate theoretical knowledge of three-phase systems	describe three-phase circuit fundamentals

## Range of Variables

**three-phase services** include: temporary service, overhead, underground, single and multiple metering

**service components** include: metering equipment, supports, enclosures, raceways, conduits, panels, switchgear, service entrance equipment, service mast, point of attachment

**service conductors** include: wire, cables, conductors

**fasteners** include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

**metering equipment** includes: meter sockets, CTs, VTs, enclosures, meter mounting equipment, associated secondary wiring

### **B-7.04** Maintains utility and non-utility three-phase supply services and metering equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-7.04.01P	obtain detailed description of malfunction	malfunction issues and information are obtained from <b>facility sources</b> and documented
B-7.04.02P	select tools and equipment	tools and equipment are selected according to task
B-7.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-7.04.04P	determine course of action	course of action is determined according to type of malfunction and availability of replacement parts
B-7.04.05P	repair malfunctioning components	repaired components are operational according to as-built specifications
B-7.04.06P	select replacement components	OEM or equivalent replacement components are selected
B-7.04.07P	install replacement components	OEM or equivalent replacement components are installed according to as-built or equivalent specifications with minimal disruptions
B-7.04.08P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' recommendations
B-7.04.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation

B-7.04.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-7.04.11P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> , and test results documented
B-7.04.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-7.04.13P	update maintenance log	maintenance log is updated to reflect tasks performed

### Range of Variables

**facility sources** (for information) include: operators, maintenance personnel, supervisor, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, phase rotation meters, insulation resistance testers, TDR, non-contact infrared sensors

### Knowledge

	Learning Outcomes	Learning Objectives
B-7.04.01L	demonstrate knowledge of three-phase systems	describe three-phase circuit fundamentals
B-7.04.02L	demonstrate knowledge of procedures to service and maintain three-phase services and their components	identify tools and equipment used to service and maintain three-phase services and their components, and describe their applications and procedures for use
		describe procedures to maintain three-phase services and their components

## Task B-8 Installs and maintains protection devices

### Task Descriptor

Overcurrent protection devices provide protection against excessive currents and short circuits to service entrance, feeder and branch circuit conductors, and equipment. Ground fault protection devices provide protection against shock and current leakage and are usually used in conjunction with overcurrent devices. Arc fault protection devices provide protection from the effects of arc faults by de-energizing the circuit when an arc fault is detected. These devices may also have overcurrent protection for the circuit. Surge protection devices prevent transient voltages from entering or leaving the system. Under- and over-voltage devices prevent under- and over-voltage condition to protect the downstream equipment.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

Industrial electricians maintain overcurrent, ground fault, arc fault, surge protection devices and under/over voltage devices by troubleshooting, diagnosing faults, replacing devices and repairing them. They also perform maintenance on these devices to ensure they are in good operating condition.

Industrial electricians may also be responsible for maintaining and updating coordination studies (selective or non-selective coordination) for the distribution systems.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### B-8.01 Installs overcurrent protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-8.01.01P	select tools and equipment	tools and equipment are selected according to task
B-8.01.02P	determine type and rating of <b>overcurrent protection device</b>	type and rating of <b>overcurrent protection device</b> is determined according to manufacturers’ specifications, CEC requirements and matching equipment requirements
B-8.01.03P	determine type and size of <b>enclosures</b>	<b>enclosure</b> type and size are based on overcurrent protection device, environment and type of equipment
B-8.01.04P	secure <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are mounted and secured to enclosures and/or busbars using <b>hardware</b> designed for equipment
B-8.01.05P	terminate <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are connected to line and load terminals according to manufacturers’ specifications and CEC requirements

B-8.01.06P	set trip settings and ensure protection is coordinated	trip settings are set according to load requirements, coordination studies and CEC requirements
B-8.01.07P	update <b>documentation</b> and labels	branch and distribution circuits are labelled on directories and <b>documentation</b> updated
B-8.01.08P	remove and dispose of or recycle unserviceable <b>enclosures, overcurrent protection devices</b> and <b>hardware</b>	unserviceable <b>enclosures, overcurrent devices</b> and <b>hardware</b> are disposed of or recycled according to jurisdictional and federal legislations, and waste disposal requirements
B-8.01.09P	test device	<b>overcurrent protection devices</b> are tested according to manufacturers' specifications
B-8.01.10P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**overcurrent protection devices** include: fuses, breakers, relay protection

**enclosures** include: CSA classified enclosures, enclosures for hazardous locations

**hardware** includes: bolts, screws, brackets, stand-offs, cabling, transition pieces

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

Knowledge		
	Learning Outcomes	Learning Objectives
B-8.01.01L	demonstrate knowledge of <b>overcurrent protection devices</b> , their characteristics, applications and operation	identify types of <b>overcurrent protection devices</b> , and describe their characteristics and applications
		interpret information pertaining to <b>overcurrent protection devices</b> found on drawings and specifications
		explain purpose and operation of <b>overcurrent protection devices</b>
		explain effects of short-circuit current and describe associated damage to circuit
		interpret codes and regulations pertaining to <b>overcurrent protection devices</b>
		identify considerations and requirements for selecting <b>overcurrent protection devices</b>
		explain purpose of coordination studies
		explain purpose of updating <b>documentation</b>

B-8.01.02L	demonstrate knowledge of procedures to install <b>overcurrent protection devices</b>	identify tools and equipment used to install <b>overcurrent protection devices</b> , and describe their applications and procedures for use
		describe procedures to install <b>overcurrent protection devices</b>
		explain procedures to adjust trip settings

## Range of Variables

**overcurrent protection devices** include: fuses, breakers, relay protection

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

## B-8.02 Maintains overcurrent protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-8.02.01P	determine maintenance requirements	maintenance requirements are determined according to failure, commissioning documentation and manufacturers' recommendations
B-8.02.02P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation
B-8.02.03P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.02.04P	conduct <b>tests</b>	<b>tests</b> are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> and results documented
B-8.02.05P	evaluate <b>test</b> results	<b>test</b> results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-8.02.06P	update maintenance log	maintenance log is updated to reflect tasks performed
B-8.02.07P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-8.02.08P	select tools and equipment	tools and equipment are selected according to task



B-8.02.09P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-8.02.10P	determine course of action	course of action is determined according to malfunction and availability of replacement parts
B-8.02.11P	select replacement components	OEM or equivalent replacement components are selected
B-8.02.12P	install replacement components	OEM or equivalent replacement components are installed according to as-built or equivalent specifications with minimal disruptions

### Range of Variables

**tests** include: recalibration, thermographic, scheduled cycling (operation of breaker), continuity, contact resistance

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, load banks, circuit breaker tester, non-contact infrared sensors

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), utility reconfigurations, latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisor, work order, other trades

**field assessments** include: sensory inspections, technical inspections

### Knowledge

	Learning Outcomes	Learning Objectives
B-8.02.01L	demonstrate knowledge of theory used to maintain overcurrent protection devices	describe theory used to maintain overcurrent protection devices
B-8.02.02L	demonstrate knowledge of procedures to maintain overcurrent protection devices	identify tools and equipment used to maintain overcurrent protection devices, and describe their applications and procedures for use
		describe procedures used to maintain overcurrent protection devices

## B-8.03 Installs ground fault, arc fault and surge protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-8.03.01P	determine branch circuit and distribution circuit protection requirements	branch circuit and distribution circuit protection is determined according to location, environment, <b>application</b> , engineering studies, and facility and CEC requirements
B-8.03.02P	select tools and equipment	tools and equipment are selected according to task
B-8.03.03P	determine type of <b>ground fault protection devices</b> to use	<b>ground fault protection devices</b> are determined according to load, location, <b>application</b> , engineering studies, and facility and CEC requirements
B-8.03.04P	determine type of <b>arc fault protection devices</b> to use	<b>arc fault protection devices</b> are determined according to load, location, <b>application</b> , engineering studies, and facility and CEC requirements
B-8.03.05P	determine type of <b>surge protection devices</b> to use	<b>surge protection devices</b> are determined according to installation requirements, <b>application</b> , engineering studies, and facility and CEC requirements
B-8.03.06P	mount and secure protection devices	devices are mounted and secured using <b>hardware</b> designed for equipment
B-8.03.07P	terminate protection devices	conductors are terminated by removing insulation, and tightening and securing them according to manufacturers' specifications and CEC requirements
B-8.03.08P	update labels	branch and distribution circuits are labelled on directories
B-8.03.09P	remove and dispose of or recycle unserviceable protection devices	unserviceable <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b> are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements

B-8.03.10P	set and test device	<b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b> are set and tested according to specifications
B-8.03.11P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**application** includes: utilization equipment, service and distribution equipment, basic insulation level (BIL) ratings

**ground fault protection devices** include: ground fault circuit interrupter (GFCI) receptacles, GFCI breakers, non-GFCI circuit breakers and ground fault relays

**arc fault protection devices** include: combination-type arc fault circuit interrupter (AFCI) branch outlet devices, combination-type AFCI breakers

**surge protection devices** include: metal oxide varistor (MOV), zener diodes, thyristors, surge suppressors, lightning arrestors

**hardware** includes: bolts, screws, brackets, stand-offs, cabling, transition pieces, boxes, enclosures

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
B-8.03.01L	demonstrate knowledge of <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b> , their characteristics, applications and operation	identify types of <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b> , and describe their characteristics and applications
		interpret information pertaining to <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b> found on drawings and specifications
		explain purpose and operation of <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b>
		interpret codes and regulations pertaining to <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b>
		identify considerations and requirements for selecting <b>ground fault protection devices, arc fault protection devices</b> and <b>surge protection devices</b>
		explain purpose of updating <b>documentation</b>

B-8.03.02L	demonstrate knowledge of procedures to install <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b>	identify tools and equipment used to install <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b> , and describe their applications and procedures for use
		describe procedures to install <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b>

## Range of Variables

**ground fault protection devices** include: GFCI receptacles, GFCI breakers

**arc fault protection devices** include: combination-type AFCI branch outlet devices, combination-type AFCI breakers

**surge protection devices** include: MOV, zener diodes, thyristors, surge suppressors, lightning arrestors

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

## B-8.04 Maintains ground fault, arc fault and surge protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-8.04.01P	determine maintenance requirements	maintenance requirements are determined according to failure, commissioning documentation and manufacturers' recommendations
B-8.04.02P	create maintenance schedule	maintenance schedule is created according to maintenance documentation and requirements, and manufacturers' specifications
B-8.04.03P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.04.04P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> , and results documented
B-8.04.05P	update maintenance log	maintenance log is updated to reflect tasks performed
B-8.04.06P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented

B-8.04.07P	select tools and equipment	tools and equipment are selected according to task
B-8.04.08P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-8.04.09P	determine course of action	course of action is determined according to malfunction and availability of replacement parts
B-8.04.10P	select replacement components	OEM or equivalent replacement components are selected
B-8.04.11P	install replacement components	OEM or equivalent replacement components are installed according to as-built or manufacturers' specifications with minimal disruptions

## Range of Variables

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, non-contact infrared sensors

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

Knowledge		
	Learning Outcomes	Learning Objectives
B-8.04.01L	demonstrate knowledge of theory used to maintain <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b>	describe theory used to maintain <b>ground fault protection devices</b>
		describe theory used to maintain <b>arc fault protection devices</b>
		describe theory used to maintain <b>surge protection devices</b>
B-8.04.02L	demonstrate knowledge of procedures to maintain <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b>	identify tools and equipment used to service and maintain <b>ground fault protection devices</b> , <b>arc fault protection devices</b> and <b>surge protection devices</b> , and describe their applications and procedures for use
		describe procedure to maintain <b>ground fault protection devices</b>

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describe procedure to maintain **arc fault protection devices**

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describe procedure to maintain **surge protection devices**

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## Range of Variables

**ground fault protection devices** include: GFCI receptacles, GFCI breakers

**arc fault protection devices** include: combination-type AFCI branch outlet devices, combination-type AFCI breakers

**surge protection devices** include: MOV, zener diodes, thyristors, surge suppressors, lightning arrestors

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## **B-8.05** Installs under- and over-voltage protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-8.05.01P	determine type of <b>under- and over-voltage protection devices</b> to use	<b>under- and over-voltage protection devices</b> are determined according to installation and CEC requirements
B-8.05.02P	select tools and equipment	tools and equipment are selected according to task
B-8.05.03P	mount <b>under- and over-voltage protection devices</b>	<b>under- and over-voltage protection devices</b> are mounted and secured using <b>hardware</b> designed for equipment
B-8.05.04P	connect <b>under- and over-voltage protection devices</b>	<b>under- and over-voltage protection devices</b> are connected to circuit according to specifications, and AHJ, CSA and CEC requirements
B-8.05.05P	set and test <b>under- and over-voltage protection devices</b>	<b>under- and over-voltage protection devices</b> are set and tested according to manufacturers' specifications
B-8.05.06P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**under- and over-voltage protection devices** include: protective relays, sensors, voltage transformer (VT)

**hardware** includes: bolts, screws, brackets, stand-offs, cabling, transition pieces, boxes, enclosures

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

## Knowledge

	Learning Outcomes	Learning Objectives
B-8.05.01L	demonstrate knowledge of <b><i>under- and over-voltage protection devices</i></b> , their characteristics, applications and operation	interpret information pertaining to <b><i>under- and over-voltage protection devices</i></b> found on drawings and specifications
		explain purpose and operation of <b><i>under- and over-voltage protection devices</i></b>
		identify types of <b><i>under- and over-voltage protection devices</i></b> , and describe their characteristics and applications
		identify considerations and requirements for selecting <b><i>under- and over-voltage protection devices</i></b>
B-8.05.02L	demonstrate knowledge of procedures to install <b><i>under- and over-voltage protection devices</i></b>	explain purpose of updating <b><i>documentation</i></b>
		identify tools and equipment used to install <b><i>under- and over-voltage protection devices</i></b> , and describe their applications and procedures for use
		describe procedures to install <b><i>under- and over-voltage protection devices</i></b>

### Range of Variables

***under- and over-voltage protection devices*** include: protective relays, sensors, VTs

***documentation*** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

## B-8.06 Maintains under- and over-voltage protection devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
B-8.06.01P	determine maintenance requirements	maintenance requirements are determined according to failure, commissioning documentation and manufacturers' specifications
B-8.06.02P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation, and manufacturers' specifications
B-8.06.03P	follow maintenance schedule	maintenance tasks are done according to established schedule

B-8.06.04P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> , and results documented
B-8.06.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-8.06.06P	update maintenance log	maintenance log is updated to reflect tasks performed
B-8.06.07P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-8.06.08P	consult drawings and documentation	drawings and documentation are consulted prior to performing field assessments
B-8.06.09P	select tools and equipment	tools and equipment are selected according to task
B-8.06.10P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results to ensure device operates according to manufacturers' specifications
B-8.06.11P	determine course of action	course of action is determined according to type of malfunction and availability of replacement parts
B-8.06.12P	select replacement components	OEM or equivalent replacement components are selected
B-8.06.13P	install replacement components	OEM or equivalent replacement components are installed according to as-built or manufacturers' specifications with minimal disruptions

## Range of Variables

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, panel meter calibrator, non-contact infrared sensor, relay test sets

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections



## Knowledge

	Learning Outcomes	Learning Objectives
B-8.06.01L	demonstrate knowledge of procedures to maintain <b><i>under- and over-voltage protection devices</i></b>	identify tools and equipment used to maintain <b><i>under- and over-voltage protection devices</i></b> , and describe their applications and procedures for use
		describe procedures to maintain <b><i>under-voltage protection devices</i></b>
		describe procedures to maintain <b><i>over-voltage protection devices</i></b>
		explain purpose of updating <b><i>documentation</i></b>

### Range of Variables

***under- and over-voltage protection devices*** include: protective relays, sensors, VTs

***documentation*** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

## Task B-9 Installs and maintains low-voltage distribution systems

### Task Descriptor

Distribution equipment provides power for all electrical systems and equipment. Low voltage is any voltage exceeding 30 V AC but not exceeding 1000 V AC or exceeding 42.4 V DC but not exceeding 1060 V DC . This equipment allows for safe utilization of electricity. This task does not include Class 1 and Class 2 systems.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

Industrial electricians maintain distribution equipment by troubleshooting, diagnosing faults and repairing them. They also perform maintenance on the equipment to ensure it is in good operating condition.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### B-9.01 Installs low-voltage distribution equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-9.01.01P	determine size and type of <b>low-voltage power distribution equipment</b> , and type of <b>enclosure</b>	size and type of <b>low-voltage power distribution equipment</b> , and type of <b>enclosure</b> are selected according to calculated load, location conditions, drawings, and facility and CEC requirements
B-9.01.02P	determine layout and location of <b>low-voltage power distribution equipment</b>	<b>low-voltage power distribution equipment</b> are laid out according to drawings, manufacturers’ specifications and CEC requirements
B-9.01.03P	select tools and equipment	tools and equipment are selected according to task
B-9.01.04P	install and secure <b>low-voltage power distribution equipment</b>	<b>low-voltage power distribution equipment</b> is securely mounted to structure according to manufacturers’ specifications, CEC requirements, and drawings and documentation
B-9.01.05P	install feeder and supply conductors	feeder and supply conductors are installed without damage to insulation, without stress, and neutral and phase conductors are colour-coded according to CEC requirements

B-9.01.06P	terminate feeder and supply conductor connections	conductors are terminated by removing insulation, applying antioxidant where required, and tightening and securing them according to manufacturers' specifications and CEC requirements
B-9.01.07P	conduct tests of <b>low-voltage power distribution equipment</b> and feeders	<b>low-voltage power distribution equipment</b> and feeders are tested, connected and function according to application requirements
B-9.01.08P	identify information on <b>low-voltage power distribution equipment</b>	<b>low-voltage power distribution equipment</b> is labelled according to job, CEC and facility requirements
B-9.01.09P	remove and dispose of or recycle unserviceable <b>low-voltage power distribution equipment</b>	unserviceable <b>low-voltage power distribution equipment, enclosures,</b> and feeder and supply conductors are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
B-9.01.10P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

## Range of Variables

**low-voltage power distribution equipment** includes: panels, sub-panels, power distribution centres (PDC), switchboards, breakers, fuses, disconnects, transfer switches, racking equipment, CTs, VTs, busbars, splitters, motor control centers (MCC), transformers

**enclosures** include: CSA enclosures, enclosures for hazardous locations

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

## Knowledge

	Learning Outcomes	Learning Objectives
B-9.01.01L	demonstrate knowledge of <b>low-voltage power distribution equipment</b> , their characteristics, applications and operation	interpret codes and regulations pertaining to <b>low-voltage power distribution equipment</b>
		interpret information pertaining to <b>low-voltage power distribution equipment</b> found on drawings and specifications
		identify types of <b>low-voltage power distribution equipment</b> , and describe their characteristics and applications
		identify <b>considerations</b> and requirements for selecting <b>low-voltage power distribution equipment</b> and <b>enclosures</b>
B-9.01.02L	demonstrate knowledge of procedures to install <b>low-voltage power distribution equipment</b>	identify tools and equipment used to install <b>low-voltage power distribution equipment</b> , and describe their applications and procedures for use

describe procedures to install **low-voltage power distribution equipment**

describe procedures to connect **low-voltage power distribution equipment**

describe procedures for transporting and moving electrical equipment

## Range of Variables

**low-voltage power distribution equipment** includes: panels, sub-panels, PDCs, switchboards, breakers, fuses, disconnects, transfer switches, racking equipment, CTs, VTs, busbars, splitters, MCCs, transformers

**considerations** include: load, voltage ratings, required circuit capacity, available fault currents

**enclosures** include: CSA enclosures, enclosures for hazardous locations

## B-9.02 Maintains low-voltage distribution equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-9.02.01P	obtain detailed description of malfunction	malfunction issues and information are obtained from <b>facility sources</b> and documented
B-9.02.02P	select tools and equipment	tools and equipment are selected according to task
B-9.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-9.02.04P	determine course of action	course of action is determined according to type of malfunction identified and availability of replacement parts
B-9.02.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-9.02.06P	select replacement components	OEM or equivalent replacement components are selected
B-9.02.07P	install replacement components	OEM or equivalent replacement components are installed according to as-built or manufacturers' specifications with minimal disruptions

B-9.02.08P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' specifications
B-9.02.09P	create maintenance schedule	maintenance schedule is created according to maintenance documentation and requirements, and manufacturers' specifications
B-9.02.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-9.02.11P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> , and results documented
B-9.02.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-9.02.13P	update maintenance log	maintenance log is updated to reflect tasks performed

### Range of Variables

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, non-contact infrared sensors

### Knowledge

	Learning Outcomes	Learning Objectives
B-9.02.01L	demonstrate knowledge of procedures to maintain <b>low-voltage distribution equipment</b>	identify tools and equipment used to maintain <b>low-voltage distribution equipment</b> , and describe their applications and procedures for use  describe procedures to maintain <b>low-voltage distribution equipment</b> and their components

### Range of Variables

**low-voltage distribution equipment** includes: panels, sub-panels, PDCs, switchboards, breakers, fuses, disconnects, transfer switches, racking equipment, CTs, VTs, busbars, splitters, MCCs, transformers

## Task B-10 Installs and maintains power conditioning systems

### Task Descriptor

Power conditioning systems include filters, capacitors and line reactors, and are used to provide a smooth sinusoidal alternating current (AC) wave thereby delivering a voltage of a constant level and power factor characteristics that enable load equipment to function as designed (reduction in harmonics).

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

Industrial electricians maintain power conditioning and uninterruptible power supply (UPS) by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure these systems are in good operating condition.

For the purpose of this standard, “maintain” includes inspections, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### B-10.01 Installs power conditioning systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-10.01.01P	analyze system to assess <b>conditions</b> that require power conditioning	system is analyzed, and voltage and power quality characteristics that are outside of the standards are identified
B-10.01.02P	select tools and equipment	tools and equipment are selected according to task
B-10.01.03P	identify type of power conditioning required	type of power conditioning is identified according to system requirements and local supply authority
B-10.01.04P	perform calculations to size power conditioning and UPS <b>components</b>	power conditioning and UPS <b>components</b> are sized according to requirements of application
B-10.01.05P	install <b>components</b>	<b>components</b> are securely installed according to manufacturers' specifications and CEC requirements, and mounted matching building lines using <b>fasteners</b> designed to attach to material of support structure
B-10.01.06P	terminate and interconnect <b>components</b>	<b>components</b> are terminated and interconnected according to electrical drawings, specifications, and job and CEC requirements

B-10.01.07P	analyze system output	system output is analyzed to ensure effectiveness of power conditioning installation and test results reflect improved power quality
B-10.01.08P	conduct tests of power conditioning and UPS systems	power conditioning and UPS systems are tested after installation, connected and function according to application requirements, and results documented
B-10.01.09P	remove and dispose of unserviceable power conditioning and UPS components	unserviceable power conditioning and UPS components are removed and disposed of according to jurisdictional and federal legislation, with minimal impact to environment
B-10.01.10P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes carried out

### Range of Variables

**conditions** include: harmonics, power factor correction, transient voltages and current, induced frequencies

**components** include: batteries, transformers, capacitors, shunt coils, diodes, reactors, synchronous condensers (motors), filters

**fasteners** include: screws, bolts, straps, inserts, anchors, wedge clamps, seismic restraints

**documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, maintenance logs, terminal identification

### Knowledge

	Learning Outcomes	Learning Objectives
B-10.01.01L	demonstrate knowledge of power conditioning and UPS systems, and their applications	interpret codes and regulations pertaining to power conditioning and UPS systems
		explain power quality and its impact on equipment operation
		explain single-phase and three-phase power factor correction, and its associated calculations
		identify types of <b>power factor correction equipment</b> , and describe their characteristics, applications and operation
		identify <b>equipment used to reduce harmonics</b> in power distribution systems, and describe their characteristics, applications and operation
		identify types of <b>UPS equipment</b> used in power distribution system conditioning, and describe their characteristics, applications and operation

		identify hazards with UPS systems when working with batteries, multiple energy sources, emergency and alternate power sources, and capacitors
B-10.01.02L	demonstrate knowledge of procedures to install power conditioning and UPS systems	identify tools and equipment used to install power conditioning and UPS systems, and describe their applications and procedures for use
		describe procedures to install power conditioning and UPS systems

## Range of Variables

**power factor correction equipment** includes: synchronous condensers (motors), reactors, capacitors  
**equipment used to reduce harmonics** includes: zero sequence/passive and active filters, K-rated or zig zag transformers and capacitors

**UPS equipment** includes: online, offline, online interactive, maintenance bypass and static bypass, batteries and battery charging systems

## B-10.02 Maintains power conditioning systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-10.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-10.02.02P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-10.02.03P	determine course of action	course of action is determined according to type of malfunction identified and availability of replacement parts
B-10.02.04P	select tools and equipment	tools and equipment are selected according to task
B-10.02.05P	repair malfunctioning <b>components</b>	<b>components</b> are repaired and tested to ensure they are operational according to manufacturers' specifications
B-10.02.06P	select replacement <b>components</b>	OEM or equivalent replacement <b>components</b> are selected



B-10.02.07P	install replacement <b>components</b>	OEM or equivalent replacement <b>components</b> are installed according to as-built or manufacturers' specifications with minimal disruptions
B-10.02.08P	conduct tests of power conditioning, UPS and surge suppression systems	power conditioning, UPS and surge suppression systems are tested after repair, connected and function according to application requirements
B-10.02.09P	<b>clean and adjust</b> components	power conditioning, UPS and surge suppression system <b>components</b> are <b>cleaned and adjusted</b> to restore to optimal conditions
B-10.02.10P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' specifications
B-10.02.11P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation, and manufacturers' specifications
B-10.02.12P	record tests in maintenance schedule	operational problems identified in tests are documented in maintenance schedule data with detailed notations
B-10.02.13P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-10.02.14P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** include: battery load testers, multimeters, voltmeters, ammeters, power quality analyzers, oscilloscopes, thermographic imaging devices, non-contact infrared sensor

**components** include: batteries, battery chargers, transformers, capacitors, shunt coils, diodes, reactors, synchronous condensers (motors), filters, fuses, UPS

**cleaning and adjusting procedures** include: cleaning fans and filters, load testing batteries, adjusting cabinets and door seals

## Knowledge

	Learning Outcomes	Learning Objectives
B-10.02.01L	demonstrate knowledge of power conditioning systems, their <b>components</b> , characteristics and applications	interpret codes and regulations pertaining to power conditioning
		explain power quality and its impact on equipment operation
		explain single-phase and three-phase power factor correction, and its associated calculations
		identify types of <b>power factor correction equipment</b> , and describe their characteristics, applications and operation
		identify <b>equipment used to reduce harmonics</b> in power distribution systems, and describe their characteristics, applications and operation
		identify hazards with power conditioning systems when working with capacitors
B-10.02.02L	demonstrate knowledge of procedures to service and maintain power conditioning systems and their <b>components</b>	identify tools and equipment used to service and maintain power conditioning systems and their <b>components</b> , and describe their applications and procedures for use
		describe procedures to service and maintain power conditioning systems

### Range of Variables

**components** include: batteries, battery chargers, transformers, capacitors, shunt coils, diodes, reactors, synchronous condensers (motors), filters

**power factor correction equipment** includes: synchronous condensers (motors), capacitors, inverters (renewable energy)

**equipment used to reduce harmonics** includes: zero sequence/passive and active filters, K-rated and zig zag transformers and capacitors

**surge suppression equipment** includes: capacitors, shunt coils and diodes

## Task B-11 Installs and maintains bonding, grounding and ground-fault protection and detection systems

### Task Descriptor

Bonding and grounding systems are used to protect life from shock and equipment from transient and fault current. Bonding is a path for fault current and keeps everything at the same potential. Grounding is a path for connecting equipment to ground to maintain equal potential. Ground fault protection systems are used to detect electrical current leakage and de-energize. They also detect and indicate the presence of ground fault, as in an ungrounded system.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes troubleshooting, maintaining and repairing activities.

### B-11.01 Installs grounding systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-11.01.01P	select tools and equipment	tools and equipment are selected according to task
B-11.01.02P	determine type of <b>grounding electrodes</b>	<b>grounding electrodes</b> are determined according to location conditions, engineering specifications, and AHJ, CSA and CEC requirements
B-11.01.03P	determine grounding conductor size	ground conductor size is determined according to supply voltage, engineering specifications, and AHJ, CSA and CEC requirements
B-11.01.04P	determine layout and location of <b>grounding system components</b>	layout allows for installation of grounding electrodes, routing of grounding conductor, and point of termination at source of supply and service equipment according to AHJ, CSA and CEC requirements, and supply authority
B-11.01.05P	install <b>grounding system components</b>	<b>grounding system components</b> are installed according to layout, drawings, location conditions, and AHJ, CSA and CEC requirements
B-11.01.06P	terminate and interconnect <b>grounding system components</b>	<b>grounding system components</b> are terminated and interconnected according to drawings, and AHJ, CSA and CEC requirements

B-11.01.07P	perform ground resistance and continuity tests	ground resistance and continuity tests are performed using <b>ground testing equipment</b> and documented
B-11.01.08P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**grounding electrodes** include: manufactured electrodes (rods, plates, clamps), field assembled (buried copper conductors), in-situ (metallic water pipes, metallic pilings, reinforcing steel)

**grounding system components** include: grounding electrodes, grounding conductors, grounding connectors (compression, mechanical and exothermic)

**ground testing equipment** includes: ground loop impedance tester, megohmmeter, multimeter

## Knowledge

	Learning Outcomes	Learning Objectives
B-11.01.01L	demonstrate knowledge of grounding methods and equipment	interpret codes, drawings, specifications and regulations pertaining to grounding
		identify grounding methods, and describe their characteristics and applications
		identify grounding conductors, equipment and components, and describe their characteristics and applications
		identify considerations and requirements for selecting grounding conductors, methods, equipment and components
		explain purpose of grounding
B-11.01.02L	demonstrate knowledge of procedures to install grounding systems	explain differences between grounding and bonding, and identify situations where interconnection is required
		identify tools and equipment used to install grounding systems, and describe their applications and procedures for use
		describe procedures to install grounding systems
		describe procedures to determine grounding conductor size

## B-11.02 Maintains grounding systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-11.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-11.02.02P	select tools and equipment	tools and equipment are selected according to task
B-11.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-11.02.04P	determine course of action	course of action is determined according to type of malfunction identified
B-11.02.05P	repair malfunctioning <b>grounding system components</b>	repaired <b>grounding system components</b> are operational
B-11.02.06P	select replacement <b>grounding system components</b>	OEM or equivalent replacement <b>grounding system components</b> are selected
B-11.02.07P	install replacement <b>grounding system components</b>	OEM or equivalent replacement <b>grounding system components</b> are installed according to as-built, manufacturers' specifications and CEC requirements with minimal disruptions
B-11.02.08P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' specifications
B-11.02.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation, and manufacturers' specifications
B-11.02.10P	follow maintenance schedule	maintenance tasks are done according to established schedule and documented
B-11.02.11P	conduct tests	tests are conducted according to established maintenance schedule and commissioning documentation using <b>diagnostic and test equipment</b> , and results documented

B-11.02.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-11.02.13P	update maintenance log	maintenance log is updated to reflect tasks performed

### Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, insulation resistance testers, ground loop impedance tester

**grounding system components** include: grounding electrodes, grounding conductors, grounding connectors (mechanical, compression and exothermic)

Knowledge		
	Learning Outcomes	Learning Objectives
B-11.02.01L	demonstrate knowledge of procedures to maintain grounding systems and <b>grounding system components</b>	identify tools and equipment used to maintain grounding systems and <b>grounding system components</b> , and describe their applications and procedures for use
		describe procedures to maintain grounding systems and <b>grounding system components</b>

### Range of Variables

**grounding system components** include: grounding electrodes, grounding conductors, grounding connectors (mechanical, compression and exothermic)

## B-11.03 Installs bonding systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-11.03.01P	determine bonding method	bonding method is determined according to environment, amperage, voltage, mechanical protection, and conductor material and size
B-11.03.02P	determine bonding conductor size	conductor size is determined according to engineering specifications, and AHJ, CSA and CEC requirements
B-11.03.03P	select tools and equipment	tools and equipment are selected according to task
B-11.03.04P	determine layout and location of <b>bonding components</b>	<b>bonding components</b> are laid out according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements
B-11.03.05P	install <b>bonding components</b>	<b>bonding components</b> are installed to ensure continuity between non-current carrying components of electrical systems and other metallic components (equipotential plane), and to facilitate function of overcurrent devices (fault current), according to layout, location conditions, drawings, and AHJ, CSA and CEC requirements
B-11.03.06P	terminate and interconnect <b>bonding components</b>	<b>bonding components</b> are terminated and interconnected according to drawings, specifications, and AHJ, CSA and CEC requirements
B-11.03.07P	perform continuity and resistance tests	continuity and resistance tests are performed using <b>testing equipment</b> and documented
B-11.03.08P	update documentation	documentation is updated to reflect changes carried out

### Range of Variables

**bonding components** include: metallic raceways, cables, grounding bushings, copper or aluminum conductors, antioxidants, connectors (mechanical, compression and exothermic), lock nuts, terminations  
**testing equipment** includes: megohmmeter, multimeter

## Knowledge

	Learning Outcomes	Learning Objectives
B-11.03.01L	demonstrate knowledge of bonding methods and equipment	interpret codes, drawings, specifications and regulations pertaining to bonding
		identify bonding methods, and describe their characteristics and applications
		identify bonding conductors, equipment and components, and describe their characteristics and applications
		identify considerations and requirements for selecting bonding conductors, methods, equipment and components
		explain purpose of, and differences between grounding and bonding, and identify situations where interconnection is required
B-11.03.02L	demonstrate knowledge of procedures to install bonding systems	identify tools and equipment used to install bonding systems, and describe their applications and procedures for use
		describe procedures to install bonding systems
		describe procedures to determine bonding conductor size

### B-11.04 Maintains bonding systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
B-11.04.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-11.04.02P	select tools and equipment	tools and equipment are selected according to task
B-11.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-11.04.04P	determine course of action	course of action is determined according to malfunction identified
B-11.04.05P	repair malfunctioning <b>bonding components</b>	repaired <b>bonding components</b> are operational according to AHJ, CSA and CEC requirements



B-11.04.06P	select replacement <b>bonding components</b>	OEM or equivalent replacement <b>bonding components</b> are selected
B-11.04.07P	install replacement <b>bonding components</b>	OEM or equivalent replacement <b>bonding components</b> are installed with minimal disruptions according to AHJ, CSA and CEC requirements
B-11.04.08P	determine maintenance requirements	maintenance requirements are identified according to manufacturers' specifications and facility policies
B-11.04.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation
B-11.04.10P	follow maintenance schedule	maintenance tasks are done according to established schedule and documented
B-11.04.11P	conduct tests	tests are conducted using <b>diagnostic and test equipment</b> according to established maintenance schedule and commissioning documentation, and results documented
B-11.04.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-11.04.13P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, insulation resistance testers

**bonding components** include: metallic raceways, cables, grounding bushings, copper or aluminum conductors, antioxidants, connectors (mechanical, compression and exothermic), lock nuts, terminations

## Knowledge

	Learning Outcomes	Learning Objectives
B-11.04.01L	demonstrate knowledge of procedures to maintain bonding systems and <b>bonding components</b>	identify tools and equipment used to install bonding systems and <b>bonding components</b> , and describe their applications and procedures for use
		describe procedures to maintain bonding systems and <b>bonding components</b>

## Range of Variables

**bonding components** include: metallic raceways, cables, grounding bushings, copper or aluminum conductors, antioxidants, connectors (mechanical, compression and exothermic), lock nuts, terminations

### B-11.05 Installs ground-fault protection and detection systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-11.05.01P	determine type of <b>ground fault protection and detection system</b> required	type of <b>ground protection and fault detection system</b> required is determined according to location conditions, drawings, specifications, and facility, AHJ, CSA, and CEC requirements
B-11.05.02P	determine layout and location of <b>ground fault protection and detection system components</b>	<b>ground fault protection and detection system components</b> are laid out according to drawings, manufacturers' specifications, and facility, AHJ, CSA, and CEC requirements
B-11.05.03P	select tools and equipment	tools and equipment are selected according to task
B-11.05.04P	mount <b>ground fault protection and detection system components</b>	<b>ground fault protection and detection system components</b> are mounted using <b>fasteners</b> designed to attach to material of support structure according to drawings, manufacturers' specifications, and AHJ, CSA, and CEC requirements
B-11.05.05P	terminate and interconnect <b>ground fault protection and detection system components</b>	<b>ground fault protection and detection system components</b> are terminated and interconnected according to drawings, manufacturers' specifications, and AHJ, CSA, and CEC requirements
B-11.05.06P	set parameters for <b>ground fault protection and detection system</b>	parameters are set according to type of <b>ground protection and fault detection system</b> installed, manufacturers' specifications, coordination studies, and AHJ, CSA, and CEC requirements
B-11.05.07P	test operation of <b>ground fault protection and detection systems</b>	<b>ground protection and fault detection systems</b> are tested according to manufacturers' specifications, and results are documented
B-11.05.08P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**ground fault protection and detection systems** include: ground fault protection (solidly grounded systems), ground fault detection (ungrounded systems, impedance grounded systems, mobile equipment)

**ground fault protection and detection system components** include: CTs, VTs, resistors, relays, annunciators (horns, panels), indicators (pilot lights), reset buttons, breakers, interconnecting wiring, ground fault sensors (direct, residual or zero sequence), meters

**fasteners** include: screws, bolts, straps, inserts, anchors, wedge clamps, seismic restraints

Knowledge		
Learning Outcomes	Learning Objectives	
B-11.05.01L	demonstrate knowledge of <b>ground protection and fault detection systems</b> and <b>ground fault protection and detection system components</b> , their characteristics, applications and operation	identify types of <b>ground protection and fault detection systems</b> , and describe their characteristics and applications
		explain purpose of <b>ground fault protection and detection systems</b>
		interpret codes, drawings, specifications and regulations pertaining to <b>ground fault protection and detection systems</b>
		identify considerations and requirements for selecting type of <b>ground fault protection and detection system components</b>
B-11.05.02L	demonstrate knowledge of procedures to install <b>ground fault protection and detection systems</b> and <b>ground fault protection and detection system components</b>	identify tools and equipment used to install <b>ground fault protection and detection systems</b> and <b>ground fault protection and detection system components</b> , and describe their applications and procedures for use
		describe procedures to install <b>ground fault protection and detection systems</b> and <b>ground fault protection and detection system components</b>

## Range of Variables

**ground fault protection and detection systems** include: ground fault protection (solidly grounded systems), ground fault detection (ungrounded systems, impedance grounded systems, mobile equipment)

**ground fault protection and detection system components** include: CTs, VTs, resistors, relays, annunciators (horns, panels), indicators (pilot lights), reset buttons, breakers, interconnecting wiring, ground fault sensors (direct, residual or zero sequence), meters

## B-11.06 Maintains ground-fault protection and detection systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-11.06.01P	obtain description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-11.06.02P	select tools and equipment	tools and equipment are selected according to task
B-11.06.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-11.06.04P	determine course of action	course of action is determined according to type of malfunction identified, manufacturers' specifications and documents
B-11.06.05P	repair malfunctioning <b>ground fault protection and detection system components</b>	repaired <b>ground fault protection and detection system components</b> are operational according to AHJ, CSA and CEC requirements
B-11.06.06P	select replacement <b>ground fault protection and detection system components</b>	OEM or equivalent replacement <b>ground fault protection and detection system components</b> are selected
B-11.06.07P	install replacement <b>ground fault protection and detection system components</b>	OEM or equivalent replacement <b>ground fault protection and detection system components</b> are installed according to as-built or manufacturers' specifications, and AHJ, CSA and CEC requirements with minimal disruptions
B-11.06.08P	conduct tests	tests are conducted using <b>diagnostic and test equipment</b> according to manufacturers' specifications and established maintenance schedule, and results documented
B-11.06.09P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-11.06.10P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' specifications

B-11.06.11P	create maintenance schedule	maintenance schedule is created according to maintenance requirements and documentation, and manufacturers' specifications
B-11.06.12P	follow maintenance schedule	maintenance tasks are done according to established schedule and documented
B-11.06.13P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), utility reconfigurations, latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, megohmmeter, non-contact testers, thermal graphic cameras

**ground fault protection and detection systems** include: ground fault protection (solidly grounded systems), ground fault detection (ungrounded systems, impedance grounded systems, mobile equipment)

**ground fault protection and detection system components** include: CTs, VTs, resistors, relays, annunciators (horns, panels), indicators (pilot lights), reset buttons, breakers, interconnecting wiring, ground fault sensors (direct, residual or zero sequence), meters

Knowledge		
	Learning Outcomes	Learning Objectives
B-11.06.01L	demonstrate knowledge of procedures to maintain <b>ground fault protection and detection systems</b> and <b>ground fault protection and detection system components</b>	describe procedures to maintain <b>ground fault protection and detection systems</b> and <b>ground fault protection and detection system components</b>

## Range of Variables

**ground fault protection and detection systems** include: ground fault protection (solidly grounded systems), ground fault detection (ungrounded systems, impedance grounded systems, mobile equipment)

**ground fault protection and detection system components** include: CTs, VTs, resistors, relays, annunciators (horns, panels), indicators (pilot lights), reset buttons, breakers, interconnecting wiring, ground fault sensors (direct, residual or zero sequence), meters

## Task B-12 Installs and maintains power generating and conversion systems

### Task Descriptor

The purpose of generators is to convert kinetic energy into electricity. They can be used when power from the utility is unavailable or the system is isolated from the power grid. DC conversion systems can also be used to convert three-phase AC power to DC power without a prime mover such as 380-volt DC power supplies used in data centres.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspections, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### B-12.01 Installs alternating current (AC) generating systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-12.01.01P	determine power requirements for application	power requirements are determined by performing load calculations and tests on connected load and according to AHJ, CSA and CEC requirements
B-12.01.02P	determine type and capacity of <b>AC generating system</b> and <b>AC generating system components</b> to be installed	type and capacity of <b>AC generating system</b> and <b>AC generating system components</b> are determined according to application requirements
B-12.01.03P	select tools and equipment	tools and equipment are selected according to task
B-12.01.04P	position and mount <b>AC generating system</b> and <b>AC generating system components</b>	<b>AC generating system</b> and <b>AC generating system components</b> are positioned according to manufacturers' and job specifications, and AHJ, CSA and CEC requirements
B-12.01.05P	terminate and interconnect <b>AC generating system</b> and <b>AC generating system components</b>	<b>AC generating system</b> and <b>AC generating system components</b> are terminated and interconnected according to drawings, specifications, and job, local supply authority, AHJ, CSA and CEC requirements

B-12.01.06P	ground and bond <b>AC generating system</b> and <b>AC generating system components</b>	<b>AC generating system</b> and <b>AC generating system components</b> are grounded and bonded according to AHJ, CSA and CEC requirements
B-12.01.07P	program <b>AC generating system</b> and controls for shutdown and restart sequences	<b>AC generating system</b> is programmed and meets functionality and established parameters, and test results documented
B-12.01.08P	conduct tests of <b>AC generating system</b> and <b>AC generating system components</b>	<b>AC generating system</b> and <b>AC generating system components</b> are tested according to manufacturers' specifications, and results documented
B-12.01.09P	disconnect existing <b>AC generating system</b> and <b>AC generating system components</b> , and update documentation	<b>AC generating system</b> and <b>AC generating system components</b> are disconnected, and remaining installations are terminated according to AHJ, CSA and CEC requirements, and documentation updated
B-12.01.10P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**AC generating systems** include: single-phase, three-phase, portable, stationary, manually operated, automatically operated

**AC generating system components** include: shaft, armature and stator, bearings, frame, exciter windings, transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, protection devices, automatic voltage regulator (AVR), governor, isolators, batteries, battery chargers

## Knowledge

	Learning Outcomes	Learning Objectives
B-12.01.01L	demonstrate knowledge of <b>AC generating systems</b> and <b>AC generating system components</b> , their characteristics, applications and operation	identify types of <b>AC generating systems</b> , and describe their characteristics, applications and operation
		identify <b>AC generating system components</b> , and describe their characteristics, applications and operation
		identify considerations and requirements for selecting <b>AC generating systems</b> and <b>AC generating system components</b>
		interpret information pertaining to <b>AC generating systems</b> found on drawings and specifications
		interpret codes, standards and regulations pertaining to <b>AC generating systems</b>

B-12.01.02L	demonstrate knowledge of procedures to install <b>AC generating systems</b>	identify tools and equipment used to install <b>AC generating systems</b> , and describe their applications and procedures for use
		describe procedures to install <b>AC generating systems</b> and <b>AC generating system components</b>
		describe procedures to control output voltage, phase sequencing and frequency of AC generators
B-12.01.03L	demonstrate knowledge of procedures to interconnect <b>AC generating systems</b> with standalone or parallel operations	identify tools and equipment used to interconnect <b>AC generating systems</b> with standalone or parallel operations, and describe their applications and procedures for use
		describe procedures used to interconnect <b>AC generating systems</b> with stand-alone or parallel operations

## Range of Variables

**AC generating systems** include: single-phase, three-phase, portable, stationary, manually operated, automatically operated

**AC generating system components** include: shaft, armature and stator, bearings, frame, exciter windings, transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, protection devices, AVR, governor, isolators, batteries, battery chargers

## B-12.02 Maintains AC generating systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-12.02.01P	obtain description of operation and malfunction	detailed description of operation, malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-12.02.02P	select tools and equipment	tools and equipment are selected according to task
B-12.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-12.02.04P	identify and remove defective <b>AC generating system components</b>	defective <b>AC generating system components</b> are removed without damage to system or other components



B-12.02.05P	repair malfunctioning <b>AC generating system components</b>	repaired <b>AC generating system components</b> are operational
B-12.02.06P	select replacement <b>AC generating system components</b>	OEM or equivalent replacement <b>AC generating system components</b> are selected
B-12.02.07P	install replacement <b>AC generating system components</b>	OEM or equivalent replacement <b>AC generating system components</b> are installed with minimal disruptions and interruptions
B-12.02.08P	conduct tests of <b>AC generating systems</b>	<b>AC generating system</b> is tested according to manufacturers' specifications
B-12.02.09P	perform <b>maintenance procedures</b> to <b>AC generating system components</b>	<b>AC generating system components</b> are restored to optimal conditions
B-12.02.10P	record tests in maintenance log	maintenance log is updated to reflect maintenance tasks performed
B-12.02.11P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and comparison with specifications

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisor, work order, other trades

**AC generating systems** include: single-phase, three-phase, portable, stationary, manually operated, automatically operated

**field assessments** include: sensory inspections, technical inspections, infrared inspections

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, oscilloscopes, power quality analyzers, hi-pot testers, thermographic imaging devices, phase rotation meters, insulation resistance testers, ground loop testers

**AC generating system components** include: shaft, armature and stator, bearings, frame, exciter windings, transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, protection devices, AVR, governor, isolators, batteries, battery chargers

**maintenance procedures** include: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches, exercising fuel-driven prime movers, examining batteries

## Knowledge

	Learning Outcomes	Learning Objectives
B-12.02.01L	demonstrate knowledge of <b>AC generating systems</b> and <b>AC generating system components</b> , their characteristics, applications and operation	identify types of <b>AC generating systems</b> , and describe their characteristics, applications and operation
		identify <b>AC generating system components</b> , and describe their characteristics, applications and operation

		interpret codes and regulations pertaining to <b>AC generating systems</b>
		interpret information pertaining to <b>AC generating systems</b> found on drawings and specifications
		interpret information contained on AC generator nameplates
B-12.02.02L	demonstrate knowledge of procedures to maintain <b>AC generating systems</b>	identify tools and equipment used to maintain <b>AC generating systems</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>AC generating systems</b> and <b>AC generating system components</b>

### Range of Variables

**AC generating systems** include: single-phase, three-phase, portable, stationary, manually operated, automatically operated

**AC generating system components** include: shaft, armature and stator, bearings, frame, exciter windings, transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, protection devices, AVR, governor, isolators, batteries, battery chargers

## B-12.03 Installs direct current (DC) generating and conversion systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-12.03.01P	determine power requirements for application	power requirements are determined by performing load calculations and tests on connected load according to CEC requirements
B-12.03.02P	determine type and capacity of <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> to be installed	type and capacity of <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are determined according to application requirements
B-12.03.03P	select tools and equipment	tools and equipment are selected according to task

B-12.03.04P	position and mount <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b>	<b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are positioned according to manufacturers' specifications, and job, facility and AHJ requirements
B-12.03.05P	terminate and interconnect <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b>	<b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are terminated and interconnected according to drawings, specifications, and job, facility and CEC requirements
B-12.03.06P	ground and bond <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b>	<b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are grounded and bonded according to CEC requirements
B-12.03.07P	program <b>DC generating and conversion system</b> and controls for shutdown and restart sequences	<b>DC generating and conversion system</b> and controls are programmed according to functionality and established parameters, and test results are documented
B-12.03.08P	conduct tests of <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b>	<b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are tested according to manufacturers' specifications, and results documented
B-12.03.09P	disconnect existing <b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> , and update documentation	<b>DC generating and conversion system</b> and <b>DC generating and conversion system components</b> are disconnected, and remaining installations are terminated according to AHJ, CSA and CEC requirements, and documentation is updated
B-12.03.10P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**DC generating and conversion systems** include: portable, stationary, manually operated, automatically operated, two wire, three wire

**DC generating and conversion system components** include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, disconnecting means, shaft, armature and stator, bearings, frame, exciter windings, solid state rectifiers, transformers, silicon controlled rectifiers (SCRs), insulated gate bipolar transistors (IGBTs)

## Knowledge

	Learning Outcomes	Learning Objectives
B-12.03.01L	demonstrate knowledge of <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b> , their characteristics, applications and operation	identify <b>DC generating and conversion systems</b> , and describe their characteristics, applications and operation
		identify types of <b>DC generating and conversion system components</b> , and describe their characteristics, applications and operation
		identify <b>prime mover DC generators</b> , and describe their characteristics, applications and operation
		identify considerations and requirements for selecting <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b>
		interpret information pertaining to <b>DC generating and conversion systems</b> found on drawings and specifications
		interpret codes, standards and regulations pertaining to <b>DC generating and conversion systems</b>
B-12.03.02L	demonstrate knowledge of procedures to install and connect <b>DC generating and conversion systems</b>	identify tools and equipment used to install and connect <b>DC generating and conversion systems</b> , and describe their applications and procedures for use
		describe procedures to install <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b>
		describe procedures to connect <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b>
		describe procedures to control output voltage of <b>prime mover DC generators</b>

### Range of Variables

**DC generating and conversion systems** include: portable, stationary, manually operated, automatically operated, two wire, three wire

**DC generating and conversion system components** include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, disconnecting means, shaft, armature and stator, bearings, frame, exciter windings, solid state rectifiers, transformers, SCRs, IGBTs

**prime mover DC generators** include: series, shunt, compound

## B-12.04 Maintains DC generating and conversion systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-12.04.01P	obtain detailed description of operation and malfunction	operation, malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-12.04.02P	select tools and equipment	tools and equipment are selected according to task
B-12.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-12.04.04P	identify and remove defective <b>DC generating and conversion system components</b>	defective <b>DC generating and conversion system components</b> are removed without damage to system or other components
B-12.04.05P	repair malfunctioning <b>DC generating and conversion system components</b>	repaired <b>DC generating and conversion system components</b> are operational
B-12.04.06P	select replacement <b>DC generating and conversion system components</b>	OEM or equivalent replacement <b>DC generating and conversion system components</b> are selected
B-12.04.07P	install replacement <b>DC generating and conversion system components</b>	OEM or equivalent replacement <b>DC generating and conversion system components</b> are installed with minimal disruptions and interruptions
B-12.04.08P	conduct tests of <b>DC generating and conversion system</b>	<b>DC generating and conversion system</b> is tested after repair according to manufacturers' specifications
B-12.04.09P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-12.04.10P	perform <b>maintenance procedures</b> to <b>DC generating and conversion system components</b>	<b>DC generating and conversion system components</b> are maintained according to manufacturers' and facility specifications
B-12.04.11P	record tests in maintenance log	maintenance log is updated to reflect maintenance tasks performed

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**DC generating and conversion systems** include: portable, stationary, manually operated, automatically operated, two wire, three wire

**field assessments** include: sensory inspections, technical inspections, infrared inspection

**diagnostic and test equipment** includes: multimeters, voltage testers, ammeters, hi-pot testers, thermographic imaging devices, insulation resistance testers, ground loop testers

**DC generating and conversion system components** include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, disconnecting means, solid state rectifiers, transformers, SCRs, IGBTs

**maintenance procedures** include: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, adjusting and setting brushes, cleaning switches, exercising fuel-driven prime movers, undercutting and dressing commutators, replace rectifiers

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
B-12.04.01L	demonstrate knowledge of <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b> , their characteristics, applications and operation	identify <b>DC generating and conversion systems</b> , and describe their characteristics, applications and operation
		identify types of <b>DC generating and conversion system components</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to <b>DC generating and conversion systems</b>
		interpret information pertaining to <b>DC generating and conversion systems</b> found on drawings and specifications
		interpret information contained on prime mover DC generator nameplates
B-12.04.02L	demonstrate knowledge of procedures to maintain <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b>	identify tools and equipment used to maintain <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>DC generating and conversion systems</b> and <b>DC generating and conversion system components</b>

## Range of Variables

**DC generating and conversion systems** include: portable, stationary, manually operated, automatically operated, two wire, three wire

**DC generating and conversion system components** include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, shaft, armature and stator, bearings, frame, exciter windings, solid state rectifiers, transformers, SCRs, IGBTs

## Task B-13 Installs and maintains renewable energy generating and energy storage systems

### Task Descriptor

Renewable energy generating systems can be used as a primary power source or a supplementary source to the utility supply. These systems can also feed energy back to the power grid. For the purpose of this standard, alternative systems are considered non-utility systems. Renewable systems are systems such as solar, fuel cell, wind, tidal or hydrokinetic powered that use renewable sources of energy. Energy storage systems can also be used independently of renewable energy generating systems.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspections, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### B-13.01 Installs renewable energy generating and energy storage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-13.01.01P	determine energy requirements for application	calculations are performed according to applicable energy requirements, production requirements, historical data and CEC requirements
B-13.01.02P	determine capacity of <b>renewable energy generating system</b>	size and capacity of <b>renewable energy generating system</b> are determined according to CEC requirements
B-13.01.03P	determine type of <b>renewable energy generating system connection</b>	<b>renewable energy generating system connection</b> type is determined according to drawings and specifications
B-13.01.04P	select tools and equipment	tools and equipment are selected according to task

B-13.01.05P	determine type of <b>energy storage system</b>	type of <b>energy storage system</b> is determined according to technology and location limitations
B-13.01.06P	determine capacity of <b>energy storage system</b>	capacity of <b>energy storage system</b> is determined according to calculations and facility demand
B-13.01.07P	position and mount <b>renewable energy generating systems</b> , their <b>components</b> , and <b>energy storage system components</b>	<b>renewable energy generating systems</b> , <b>renewable energy generating system components</b> , and <b>energy storage system components</b> are securely mounted using <b>fasteners</b> designed to attach to material of support structure according to manufacturers' specifications, and facility, AHJ, CSA and CEC requirements
B-13.01.08P	terminate and interconnect <b>renewable energy generating system</b> and <b>renewable energy generating system components</b>	<b>renewable energy generating system</b> and <b>renewable energy generating system components</b> are terminated and interconnected according to drawings, specifications, local supply authority, and job and CEC requirements
B-13.01.09P	terminate and interconnect <b>energy storage system</b> and <b>energy storage system components</b>	<b>energy storage system</b> and <b>energy storage system components</b> are terminated and interconnected according to drawings, specifications, local supply authority, and job and CEC requirements
B-13.01.10P	conduct tests of <b>renewable energy generating system</b> and <b>renewable energy generating system components</b>	<b>renewable energy generating system</b> and <b>renewable energy generating system components</b> are tested, functional and connected according to application requirements and manufacturers' specifications, and results documented
B-13.01.11P	conduct tests of <b>energy storage system</b> and <b>energy storage system components</b>	<b>energy storage system</b> and <b>energy storage system components</b> are tested, functional and connected according to application requirements and manufacturers' specifications, and results documented
B-13.01.12P	determine grounding and bonding requirements	method and materials for system grounding and bonding are selected for <b>renewable energy generating system</b> according to AHJ, CSA and CEC requirements
B-13-01.13P	update documentation	documentation is updated to reflect changes carried out



## Range of Variables

**renewable energy generating systems** include: fuel cells, wind turbines, photovoltaic array, hydrokinetic, hydraulic turbine, geothermal, tidal

**renewable energy generating system connections** include: grid dependent, grid independent (stand-alone)

**renewable energy generating system components** include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects, protection devices

**energy storage system** includes: pumped hydro, compressed air energy storage, batteries (various technologies)

**energy storage system components** include: transfer switches, inverters, isolation disconnects, controls, battery chargers, protection devices

**fasteners** include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

Knowledge		
	Learning Outcomes	Learning Objectives
B-13.01.01L	demonstrate knowledge of <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b> , their characteristics, applications and operation	identify types of <b>renewable energy generating systems</b> , and describe their characteristics, applications and operation
		identify <b>renewable energy system components</b> , and describe their characteristics, applications and operation
		identify types of <b>renewable energy generating system connections</b>
		interpret codes and regulations pertaining to <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>
B-13.01.02L	demonstrate knowledge of <b>energy storage systems</b> and <b>energy storage system components</b> , characteristics, applications and operation	identify types of <b>energy storage systems</b> , and describe their characteristics, applications and operation
		identify <b>energy storage system components</b> , and describe their characteristics, applications and operation
		identify types of energy storage system connections
		interpret codes and regulations pertaining to <b>energy storage systems</b> and <b>energy storage system components</b>
B-13.01.03L	demonstrate knowledge of procedures to install and connect <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>	identify tools and equipment used to install and connect <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b> , and describe their applications and procedures for use

		describe procedures to install <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>
		describe procedures to connect <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>
B-13.01.04L	demonstrate knowledge of procedures to install and connect <b>energy storage systems</b> and <b>energy storage system components</b>	identify tools and equipment used to install and connect <b>energy storage systems</b> and <b>energy storage system components</b> , and describe their applications and procedures for use
		describe procedures to install <b>energy storage systems</b> and <b>energy storage system components</b>
		describe procedures to connect <b>energy storage systems</b> and <b>energy storage system components</b>

## Range of Variables

**renewable energy generating systems** include: fuel cells, wind turbines, photovoltaic array, hydrokinetic, hydraulic turbine, geothermal, tidal

**renewable energy generating system connections** include: grid dependent, grid independent (stand-alone)

**renewable energy generating system components** include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects, protection devices

**energy storage system** includes: pumped hydro, compressed air energy storage, batteries (various technologies)

**energy storage system components** include: transfer switches, inverters, isolation disconnects, controls, battery chargers, protection devices

## B-13.02 Maintains renewable energy generating and energy storage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-13.02.01P	obtain description of operation and malfunction	description of operation, malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-13.02.02P	select tools and equipment	tools and equipment are selected according to task

B-13.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-13.02.04P	isolate and remove defective components	defective components are isolated and removed without damage to system or other components
B-13.02.05P	isolate grid connected sources and components	<b>renewable energy generating systems</b> are isolated from supply authority
B-13.02.06P	repair malfunctioning components	repaired components are operational according to manufacturers' specifications
B-13.02.07P	select replacement components	OEM or equivalent replacement components are selected
B-13.02.08P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions
B-13.02.09P	conduct tests of <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>	<b>renewable energy generating system</b> and <b>renewable energy generating system components</b> are tested after repair or scheduled maintenance according to commissioning documentation, and job, facility, AHJ, CSA and CEC requirements
B-13.02.10P	conduct tests on <b>energy storage systems</b> and <b>energy storage system components</b>	<b>energy storage systems</b> and <b>energy storage systems components</b> are tested after repair or scheduled maintenance according to commissioning documentation, and job, facility, AHJ, CSA and CEC requirements
B-13.02.11P	<b>lubricate, clean and adjust</b> components	<b>renewable energy generating systems</b> are restored according to manufacturers' specifications
B-13.02.12P	record tests in maintenance schedule	maintenance log is updated to reflect maintenance tasks performed
B-13.02.13P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-13.02.14P	remove and dispose of unserviceable <b>renewable energy generating system components</b> and equipment	unserviceable <b>renewable energy generating system components</b> and equipment are disposed of according to jurisdictional and federal legislation, with minimal impact to environment

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisor, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, irradiation meters, tachometers, oscilloscopes, insulation resistance testers

**renewable energy generating systems** include: fuel cells, wind turbines, photovoltaic array, hydrokinetic, hydraulic turbine, geothermal, tidal

**renewable energy generating system components** include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects

**lubrication, cleaning and adjusting procedures** include: cleaning fans and filters, adjusting cabinets and door seals, lubricating bearings and bushings, cleaning photovoltaic modules, recalibrating tracking system

**energy storage system** includes: pumped hydro, compressed air energy storage, batteries (various technologies)

**energy storage system components** include: transfer switches, inverters, isolation disconnects, controls, battery chargers, protection devices

Knowledge		
	Learning Outcomes	Learning Objectives
B-13.02.01L	demonstrate knowledge of <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b> , their characteristics, applications and operation	identify types of <b>renewable energy generating systems</b> , and describe their characteristics, applications and operation
		identify <b>renewable energy generating system components</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>
B-13.02.02L	demonstrate knowledge of <b>energy storage systems</b> , <b>energy storage system components</b> , their characteristics, applications and operation	identify types of <b>energy storage systems</b> , and describe their characteristics, applications and operation
		identify <b>energy storage system components</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to <b>energy storage systems</b> and <b>energy storage system components</b>

B-13.02.03L	demonstrate knowledge of procedures to maintain <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>	identify tools and equipment used to maintain <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>renewable energy generating systems</b> and <b>renewable energy generating system components</b>
B-13.02.04L	demonstrate knowledge of procedures to maintain <b>energy storage systems</b> and <b>energy storage system components</b>	identify tools and equipment used to maintain <b>energy storage systems</b> and <b>energy storage system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>energy storage systems</b> and <b>energy storage system components</b>

## Range of Variables

**renewable energy generating systems** include: fuel cells, wind turbines, photovoltaic array, hydrokinetic, hydraulic turbine, geothermal, tidal

**renewable energy generating system components** include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects

**energy storage system** includes: pumped hydro, compressed air energy storage, batteries (various technologies)

**energy storage system components** include: transfer switches, inverters, isolation disconnects, controls, battery chargers, protection devices

## Task B-14 Installs and maintains high-voltage systems

### Task Descriptor

Industrial electricians assemble, install, erect and connect equipment and cables for high voltage applications (voltages above 1 000 V AC or 1 060 V DC) such as switchyards, sub-stations, electrical vaults, electrical equipment rooms and MCCs. They use specific equipment, tests and procedures to ensure the work is performed safely due to the inherent hazards regarding high-voltage systems that can cause property damage, serious injury or death.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintains” includes inspection, troubleshooting, replacing and repairing activities.

### B-14.01 Installs high-voltage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-14.01.01P	determine installation requirements for <b>high-voltage equipment</b>	requirements for <b>high-voltage equipment</b> are determined according to drawings, manufacturers’ specifications, calculated load, location conditions, supply authority, and facility, AHJ, CSA, and CEC requirements
B-14.01.02P	select tools and equipment	tools and equipment are selected according to task
B-14.01.03P	determine layout and location of <b>high-voltage equipment</b>	<b>high-voltage equipment</b> is laid out according to drawings, manufacturers’ specifications, supply authority, and facility, AHJ, CSA and CEC requirements
B-14.01.04P	assemble <b>high-voltage equipment</b>	<b>high-voltage equipment</b> is assembled according to supply authority, manufacturers’ specifications, and job, facility, AHJ, CSA and CEC requirements
B-14.01.05P	install <b>high-voltage equipment</b>	<b>high-voltage equipment</b> is installed according to drawings, manufacturers’ specifications, and job, AHJ, CSA and CEC requirements
B-14.01.06P	terminate cables and interconnect <b>high-voltage equipment</b>	cables are terminated and <b>high-voltage equipment</b> is interconnected using busbars, cable bus, and high-voltage cabling systems according to application

B-14.01.07P	bond <b>non-current carrying metallic components</b>	<b>non-current carrying metallic components</b> are bonded to ground according to CEC requirements
B-14.01.08P	install ground grid	ground grid is installed according to AHJ, CSA and CEC requirements, and industry standards
B-14.01.09P	perform ground resistance test	ground resistance test is performed using <b>testing equipment</b> and documented
B-14.01.10P	perform <b>commissioning tests</b>	<b>commissioning tests</b> are conducted using required <b>testing standards</b> according to AHJ, CSA and CEC requirements
B-14.01.11P	install labelling and signage on <b>high-voltage equipment</b>	<b>high-voltage equipment</b> is labelled, and signage is evident according to facility, AHJ, CSA and CEC requirements
B-14.01.12P	remove and dispose of or recycle unserviceable <b>high-voltage equipment</b> , their components and <b>non-current carrying metallic components</b>	unserviceable <b>high-voltage equipment</b> , their components and <b>non-current carrying metallic components</b> are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
B-14.01.13P	update <b>documentation</b>	<b>documentation</b> is updated to reflect changes according to facility and AHJ requirements

## Range of Variables

**high-voltage equipment** includes: distribution equipment, contactors, motor starters, transformers, MCCs, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs, isolating and load breaking switches, transmission, breakers, protection devices, worker protective grounds, hot sticks

**non-current carrying metallic components** include: fences, towers, doors, enclosures, buildings

**testing equipment** includes: ground loop impedance tester, megohmmeter, proximity tester, phasing sticks, relay test sets

**commissioning tests** include: polarity, ground grid resistance, hi-pot, phasing, functionality, timing, current injection, interlocking, ultrasonic detectors, thermographic equipment

**testing standards** include: manufacturer, Institute of Electrical and Electronics Engineers (IEEE), CSA, AHJ, InterNational Electrical Testing Association (NETA)

**documentation** includes: as-builts, schematics (AC, DC), drive drawings, shop drawings, single-line drawings

## Knowledge

	Learning Outcomes	Learning Objectives
B-14.01.01L	demonstrate knowledge of <b>high-voltage equipment</b> , its characteristics, applications and operation	interpret codes, drawings, specifications and regulations pertaining to <b>high-voltage equipment</b>  identify grounding conductors, equipment and components, and describe their characteristics and applications

		identify bonding conductors, equipment and components, and describe their characteristics and applications
		explain purpose of grounding grids in relation to step and touch voltages
		explain function of <b>high-voltage equipment</b>
		identify sources of information and <b>documentation</b> for installation of <b>high-voltage equipment</b>
		explain <b>hazards</b> associated with high-voltage systems
		explain safety procedures to access high voltage environment
B-14.01.02L	demonstrate knowledge of procedures to install <b>high-voltage equipment</b>	identify tools and equipment used to install <b>high-voltage equipment</b> , and describe their applications and procedures for use
		describe procedures to install <b>high-voltage equipment</b>
		describe procedures to size and install ground grid and grounding conductors
		describe procedures to terminate and splice high-voltage conductors
		describe procedure to isolate faults by de-energizing source of energy
B-14.01.03L	demonstrate knowledge of testing procedures	identify testing procedures
		describe procedures to perform ground resistance testing and <b>commissioning testing</b> of <b>high-voltage equipment</b>

## Range of Variables

**high-voltage equipment** includes: distribution equipment, contactors, motor starters, transformers, MCCs, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs, isolating and load breaking switches, transmission, breakers, protection devices, worker protective grounds, hot sticks

**documentation** includes: as-builts, schematics (AC, DC), shop drawings, single-line drawings

**hazards** include: corona discharge, ozone gas, proximity to energized exposed equipment

**commissioning tests** include: polarity, ground grid resistance, hi-pot, phasing, functionality, timing, current injection, interlocking, ultrasonic detectors, thermographic imaging device



## B-14.02 Maintains high-voltage systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-14.02.01P	determine maintenance requirements	maintenance requirements are identified according to failure, commissioning documentation and manufacturers' specifications
B-14.02.02P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation, and manufacturers' specifications
B-14.02.03P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-14.02.04P	select tools and equipment	tools and equipment are selected according to task
B-14.02.05P	isolate components	components are isolated in order to allow for testing procedures
B-14.02.06P	conduct tests	tests are conducted according to established maintenance schedule using <b>diagnostic and test equipment</b> and results documented
B-14.02.07P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-14.02.08P	update maintenance log and <b>documentation</b>	maintenance log and <b>documentation</b> are updated to reflect maintenance tasks performed
B-14.02.09P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-14.02.10P	assess risks associated with working around <b>hazardous insulating mediums</b>	precautions are taken to lower exposure to <b>hazardous insulating mediums</b>
B-14.02.11P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-14.02.12P	determine course of action	course of action is determined according to type of malfunction identified and availability of replacement parts
B-14.02.13P	select replacement components	OEM or equivalent replacement components are selected

B-14.02.14P	install replacement components	OEM or equivalent replacement components are installed according to as-built or manufacturers' specifications and commissioning documentation with minimal disruptions
B-14.02.15P	repair malfunctioning components	repaired components are verified to be operational according to manufacturers' specifications and commissioning documentation

## Range of Variables

**diagnostic and test equipment** includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, ultrasonic audio detectors, insulation resistance testers, ground loop tester, proximity tester, relay test sets

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, drawings, as-built drawings

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**hazardous insulating mediums** include: SF<sub>6</sub>, polychlorinated biphenyl (PCB)

**field assessments** include: sensory inspections, technical inspections

Knowledge		
	Learning Outcomes	Learning Objectives
B-14.02.01L	demonstrate knowledge of procedures to maintain <b>high-voltage equipment</b> and their components	identify tools and equipment used to maintain <b>high-voltage equipment</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>high-voltage equipment</b> and their components
		interpret <b>documentation</b> related to <b>high-voltage equipment</b>
B-14.02.02L	demonstrate knowledge of procedures to maintain <b>high-voltage cables</b> and <b>high-voltage cable components</b>	identify tools and equipment used to maintain <b>high-voltage cables</b> and <b>high-voltage cable components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>high-voltage cables</b> and <b>high-voltage cable components</b>
		explain <b>hazards</b> associated with high-voltage systems
		explain safety procedures to access high-voltage environment

		describe procedure to isolate faults by de-energizing source of energy
B-14.02.03L	demonstrate knowledge of procedures to install and remove <b>temporary protective ground equipment</b>	identify tools and equipment used to install and remove <b>temporary protective ground equipment</b> , and describe their applications and procedures for use
		describe procedures to install <b>temporary protective ground equipment</b>
		describe procedures to remove <b>temporary protective ground equipment</b>

## Range of Variables

**high-voltage equipment** includes: distribution equipment, contactors, motor starters, transformers, MCCs, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs, isolating and load breaking switches, insulators, transmission, breakers, protection devices, worker protective grounds, hot sticks

**high-voltage cable components** include: potheads, stress relief terminations, strapping, bracing, splice kits

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, drawings, as-built drawings, manufacturers' specifications

**high-voltage cables** include: armoured cables (with or without shielded conductor), TC cable, trailing cables, shielded cables, bus ducts, cable bus

**hazards** include: corona discharge, ozone gas, proximity to energized exposed equipment

**temporary protective ground equipment** includes: ground clamps and straps, conductors, switchgear ground truck

## Task B-15 Installs and maintains transformers

### Task Descriptor

Industrial electricians install extra-low, low and high-voltage transformers to condition or change voltage and current values. Common transformer uses include signal control, isolation, power, distribution and transmission. Transformers are part of the distribution system and not the load.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### **B-15.01** Installs extra-low-voltage transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.01.01P	select tools and equipment	tools and equipment are selected according to task
B-15.01.02P	determine type of extra-low-voltage transformer required and its volt-ampere (VA) rating	type of extra-low-voltage transformer meets criteria for operation
B-15.01.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
B-15.01.04P	determine overcurrent devices	type and rating of overcurrent devices are determined according to CEC requirements
B-15.01.05P	install overcurrent devices	overcurrent devices are installed so that transformer is protected
B-15.01.06P	remove existing extra-low-voltage transformer prior to upgrade	extra-low-voltage transformers are removed with minimal impact to surrounding equipment and interruption to operation
B-15.01.07P	position and mount extra-low-voltage transformer	extra-low-voltage transformer is positioned and mounted according to drawings and CEC requirements
B-15.01.08P	connect transformer terminations	transformer terminations are connected according to drawings and CEC requirements
B-15.01.09P	check extra-low-voltage transformer after installation	extra-low-voltage transformer is operational according to application requirements

B-15.01.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.01.11P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

### Range of Variables

**documentation** includes: schematic diagrams and drawings, maintenance schedules, as-built drawings, manufacturers' specifications

<b>Knowledge</b>		
	Learning Outcomes	Learning Objectives
B-15.01.01L	demonstrate knowledge of extra-low-voltage transformers, their characteristics, applications and operation	identify types of extra-low-voltage transformers, and describe their characteristics, applications and operation
		identify code requirements pertaining to extra-low-voltage transformers
		interpret information contained on extra-low-voltage transformer nameplates
		identify <b>extra-low-voltage transformer components</b> , and describe their characteristics and applications
B-15.01.02L	demonstrate knowledge of procedures to install extra-low-voltage transformers	identify tools and equipment used to install extra-low-voltage transformers, and describe their applications and procedures for use
		describe procedures to install extra-low-voltage transformers

### Range of Variables

**extra-low-voltage transformer components** include: casings, core, primary and secondary windings, taps

## B-15.02 Maintains extra-low-voltage transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-15.02.02P	select tools and equipment	tools and equipment are selected according to task
B-15.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-15.02.04P	identify and remove defective extra-low-voltage transformer	defective extra-low-voltage transformer is removed without damage to system or other components
B-15.02.05P	select and install replacement extra-low-voltage transformer	replacement extra-low-voltage transformer matches application and is installed with minimal disruptions and interruptions, and according to CEC requirements
B-15.02.06P	test extra-low-voltage transformer	extra-low-voltage transformer is operational according to application, manufacturers' specifications and CEC requirements
B-15.02.07P	clean <b>extra-low-voltage transformer components</b>	<b>extra-low-voltage transformer components</b> are restored using <b>cleaning procedures</b> according to manufacturers' specifications
B-15.02.08P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.02.09P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, insulation resistance testers, thermographic imaging devices

**extra-low-voltage transformer components** include: casings, core, primary and secondary windings, taps

**cleaning procedures** include: removing contaminants

**documentation** includes: schematic diagrams and drawings, maintenance schedules, as-built drawings, manufacturers' specifications

Knowledge		
	Learning Outcomes	Learning Objectives
B-15.02.01L	demonstrate knowledge of extra-low-voltage transformers and <b>extra-low-voltage transformer components</b> , their characteristics, applications and operation	identify extra-low-voltage transformers, and describe their characteristics, applications and operation
		identify <b>extra-low-voltage transformer components</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to extra-low-voltage transformers
		interpret information pertaining to extra-low-voltage transformers found on drawings and specifications
		interpret information found on extra-low-voltage transformer nameplates
B-15.02.02L	demonstrate knowledge of procedures to maintain extra-low-voltage transformers and <b>extra-low-voltage transformer components</b>	identify tools and equipment used to maintain extra-low-voltage transformers and <b>extra-low-voltage transformer components</b> , and describe their applications and procedures for use
		describe procedures to maintain extra-low-voltage transformers and <b>extra-low-voltage transformer components</b>

## Range of Variables

**extra-low-voltage transformer components** include: casings, core, primary and secondary windings, taps

## B-15.03 Installs low-voltage single-phase transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.03.01P	determine type and rating of <b>low-voltage single-phase transformer</b> required	type (including ventilation) and rating of <b>low-voltage single-phase transformer</b> meets criteria for operation, manufacturers' specifications and AHJ requirements
B-15.03.02P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
B-15.03.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to calculations, manufacturers' specifications and CEC requirements
B-15.03.04P	select tools and equipment	tools and equipment are selected according to task
B-15.03.05P	install overcurrent devices	overcurrent devices are installed according to manufacturers' specifications and CEC requirements
B-15.03.06P	remove existing <b>low-voltage single-phase transformer</b> prior to upgrade	existing <b>low-voltage single-phase transformer</b> is removed prior to upgrade with minimal impact to surrounding equipment and interruption to operation
B-15.03.07P	position and mount <b>low-voltage single-phase transformer</b>	<b>low-voltage single-phase transformer</b> is positioned and mounted according to application, ventilation requirements, manufacturer's specifications, and facility, AHJ, CSA and CEC requirements
B-15.03.08P	connect <b>low-voltage single-phase transformers</b>	<b>low-voltage single-phase transformers</b> are connected according to CEC and <b>system requirements</b>
B-15.03.09P	select and change tap settings of <b>low-voltage single-phase transformers</b>	tap settings of <b>low-voltage single-phase transformers</b> are selected and changed such that output voltage meets application requirements
B-15.03.10P	ground and bond <b>low-voltage single-phase transformer</b>	<b>low-voltage single-phase transformer</b> is grounded and bonded according to CEC requirements
B-15.03.11P	conduct <b>tests</b> of <b>low-voltage single-phase transformer</b>	<b>low-voltage single-phase transformer</b> is tested after installation, and connected according to application, CEC requirements and manufacturers' specifications, and results documented



B-15.03.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.03.13P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**low-voltage single-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, metering rated transformers

**system requirements** include: input/output voltage, polarities, kilovolt-amperes (kVA) ratings, conductor size, overcurrent protection, disconnect means

**tests** include: insulation test, voltage test, polarity test, turn ratio tests

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

Knowledge		
	Learning Outcomes	Learning Objectives
B-15.03.01L	demonstrate knowledge of <b>low-voltage single-phase transformers</b> and <b>low-voltage single-phase transformer components</b> , their characteristics, applications and operation	identify types of <b>low-voltage single-phase transformers</b> and describe their characteristics, applications, operation and connections
		interpret codes and regulations pertaining to <b>low-voltage single-phase transformers</b>
		identify <b>low-voltage single-phase transformer components</b> , and describe their characteristics, applications and operation
		interpret information contained on low-voltage single-phase transformer nameplates
		explain <b>low-voltage single-phase transformer</b> polarity and terminal markings
		identify considerations and requirements for selecting <b>low-voltage single-phase transformers</b>
B-15.03.02L	demonstrate knowledge of procedures to install <b>low-voltage single-phase transformers</b>	identify tools and equipment used to install <b>low-voltage single-phase transformers</b> , and describe their applications and procedures for use describe

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describe procedures to install **low-voltage single-phase transformers**

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describe procedures to install **low-voltage single-phase transformers** in parallel

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### Range of Variables

**low-voltage single-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, metering rated transformers

**low-voltage single-phase transformer components** include: casing and enclosures, core, primary and secondary windings, dielectric liquid, cooling fans, on-line/off-line manual and automatic tap changers

## **B-15.04** Maintains low-voltage single-phase transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.04.01P	determine maintenance requirements	maintenance requirements are determined according to maintenance schedule and manufacturers' specifications
B-15.04.02P	conduct tests	tests are conducted according to established maintenance schedule and manufacturers' specifications using <b>diagnostic and test equipment</b> , and results documented
B-15.04.03P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.04.04P	<b>clean and adjust low-voltage single-phase transformer components</b>	<b>low-voltage single-phase transformer components</b> are <b>cleaned and adjusted</b> , and transformers are restored according to manufacturers' specifications
B-15.04.05P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications, <b>documentation</b> , and CEC requirements
B-15.04.06P	remove and dispose of or recycle unserviceable components	unserviceable components are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements

B-15.04.07P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-15.04.08P	select tools and equipment	tools and equipment are selected according to task
B-15.04.09P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-15.04.10P	select and install replacement <b>low-voltage single-phase transformer components</b>	equivalent replacement <b>low-voltage single-phase transformer components</b> match application and are installed with minimal disruptions and interruptions, and according to manufacturers' specifications, and facility and CEC requirements
B-15.04.11P	repair malfunctioning <b>low-voltage single-phase transformer components</b>	repaired <b>low-voltage single-phase transformer components</b> are operational
B-15.04.12P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**low-voltage single-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, metering rated transformers

**field assessments** include: sensory inspections, technical inspections, oil sampling

**diagnostic and test equipment** includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, insulation resistance testers, ground loop tester

**low-voltage single-phase transformer components** include: casings and enclosures, core, primary and secondary windings, dielectric liquid, cooling fans, on-line/off-line manual and automatic tap changers

**cleaning and adjustment** includes: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, vacuuming and cleaning windings

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

## Knowledge

	Learning Outcomes	Learning Objectives
B-15.04.01L	demonstrate knowledge of <b>low-voltage single-phase transformers</b> and <b>low-voltage single-phase transformer components</b> , their characteristics, applications and operation	identify <b>low-voltage single-phase transformers</b> , and describe their characteristics, applications and operation
		identify types of <b>low-voltage single-phase transformer components</b> , and describe their characteristics and applications
		interpret codes and regulations pertaining to <b>low-voltage single-phase transformers</b>
		interpret information contained on low-voltage single-phase transformer nameplates
		explain transformer polarity and terminal markings
		identify considerations and requirements for selecting <b>low-voltage single-phase transformers</b>
B-15.04.02L	demonstrate knowledge of procedures to maintain <b>low-voltage single-phase transformers</b>	identify tools and equipment used to maintain <b>low-voltage single-phase transformers</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>low-voltage single-phase transformers</b>

### Range of Variables

**low-voltage single-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, metering rated transformers

**low-voltage single-phase transformer components** include: casings and enclosures, core, primary and secondary windings, dielectric liquid, cooling fans, on-line/off-line manual and automatic tap changers

## B-15.05 Installs low-voltage three-phase transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.05.01P	determine type and rating of <b>low-voltage three-phase transformer</b> required	type (including ventilation) and rating of <b>low-voltage three-phase transformer</b> meets criteria for operation
B-15.05.02P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
B-15.05.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to calculations, manufacturers' specifications and CEC requirements
B-15.05.04P	select tools and equipment	tools and equipment are selected according to task
B-15.05.05P	install overcurrent devices	overcurrent devices are installed according to manufacturers' specifications and CEC requirements
B-15.05.06P	remove existing <b>low-voltage three-phase transformer</b> prior to upgrade	existing <b>low-voltage three-phase transformer</b> is removed prior to upgrade with minimal impact to surrounding equipment and interruption to operation
B-15.05.07P	position and mount <b>low-voltage three-phase transformer</b>	<b>low-voltage three-phase transformer</b> is positioned and mounted according to application, ventilation requirements, manufacturer's specifications, and facility, AHJ, CSA and CEC requirements
B-15.05.08P	connect <b>low-voltage three-phase transformers</b>	<b>low-voltage three-phase transformers</b> are connected according to CEC and <b>system requirements</b>
B-15.05.09P	select and change tap settings of <b>low-voltage three-phase transformers</b>	tap settings of <b>low-voltage three-phase transformers</b> are selected and changed such that output voltage meets application requirements
B-15.05.10P	ground and bond <b>low-voltage three-phase transformers</b>	transformer is grounded and bonded according to CEC requirements
B-15.05.11P	conduct <b>tests</b> of <b>low-voltage three-phase transformer</b>	<b>low-voltage three-phase transformer</b> is tested after installation, and connected according to application, manufacturers' specifications and CEC requirements, and results documented
B-15.05.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation

B-15.05.13P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.05.14P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**low-voltage three-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, wye, delta

**system requirements** include: input/output voltage, polarities, kVA ratings, conductor size, overcurrent protection, disconnect means

**tests** include: insulation test, voltage test, polarity test, turn ratio test, thermographic test

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

Knowledge		
	Learning Outcomes	Learning Objectives
B-15.05.01L	demonstrate knowledge of <b>low-voltage three-phase transformers</b> and <b>low-voltage three-phase transformer components</b> , their characteristics, applications and operation	identify types of <b>low-voltage three-phase transformers</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to <b>low-voltage three-phase transformers</b>
		identify <b>winding configurations</b> for <b>low-voltage three-phase transformers</b>
		identify <b>low-voltage three-phase transformer components</b> , and describe their characteristics and applications
		interpret information contained on low-voltage three-phase transformer nameplates
		explain <b>low-voltage three-phase transformer</b> polarity and terminal markings
		identify considerations and requirements for selecting <b>low-voltage three-phase transformers</b>
B-15.05.02L	demonstrate knowledge of procedures to install <b>low-voltage three-phase transformers</b>	identify tools and equipment used to install <b>low-voltage three-phase transformers</b> , and describe their applications and procedures for use
		describe procedures to install <b>low-voltage three-phase transformers</b>

describe procedures to install **low-voltage three-phase transformers** in parallel

describe procedures to install **low-voltage three-phase transformers** using various **winding configurations**

## Range of Variables

**low-voltage three-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, wye, delta

**winding configurations** include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag, Scott connection

**low-voltage three-phase transformer components** include: ventilation fans, casings and enclosures, core, primary and secondary windings, bushings, on-line/off-line manual and automatic tap changers, dielectric liquid

## B-15.06 Maintains low-voltage three-phase transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
B-15.06.01P	determine maintenance requirements	maintenance requirements are completed according to maintenance schedule and manufacturers' specifications
B-15.06.02P	conduct tests	tests are conducted according to established maintenance schedule and manufacturers' specifications using <b>diagnostic and test equipment</b> , and results documented
B-15.06.03P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.06.04P	<b>clean and adjust</b> components	components are <b>cleaned and adjusted</b> , and transformers are restored according to manufacturers' specifications
B-15.06.05P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.06.06P	remove and dispose of or recycle unserviceable components	unserviceable components are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements

B-15.06.07P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-15.06.08P	select tools and equipment	tools and equipment are selected according to task
B-15.06.09P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-15.06.10P	select and install replacement <b>low-voltage three-phase transformer components</b>	equivalent replacement <b>low-voltage three-phase transformer components</b> match application and are installed with minimal disruptions and interruptions, and according to manufacturers' specifications, and facility and CEC requirements
B-15.06.11P	repair malfunctioning <b>low-voltage three-phase transformer components</b>	repaired <b>low-voltage three-phase transformer components</b> are operational
B-15.06.12P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**diagnostic and test equipment** includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, phase rotation meters, insulation resistance testers, ground loop testers

**cleaning and adjustment procedures** include: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, checking external metal case (including external latching system to prevent contamination and access), vacuuming and cleaning windings

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections, oil sampling

**low-voltage three-phase transformer components** include: ventilation fans, casings and enclosures, core, primary and secondary windings, bushings, on-line/off-line manual and automatic tap changers, dielectric liquid

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications



## Knowledge

	Learning Outcomes	Learning Objectives
B-15.06.01L	demonstrate knowledge of <b>low-voltage three-phase transformers</b> and <b>low-voltage three-phase transformer components</b> , their characteristics, applications and operation	identify types of <b>low-voltage three-phase transformers</b> , and describe their characteristics, applications and operation
		identify <b>winding configurations</b> for <b>low-voltage three-phase transformers</b>
		interpret codes and regulations pertaining to <b>low-voltage three-phase transformers</b>
		identify <b>low-voltage three-phase transformer components</b> , and describe their characteristics and applications
		interpret information contained on low-voltage three-phase transformer nameplates
		explain <b>low-voltage three-phase transformer</b> polarity and terminal markings
		identify considerations and requirements for selecting <b>low-voltage three-phase transformers</b>
B-15.06.02L	demonstrate knowledge of procedures to maintain <b>low-voltage three-phase transformers</b>	identify tools and equipment used to maintain <b>low-voltage three-phase transformers</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>low-voltage three-phase transformers</b>

### Range of Variables

**low-voltage three-phase transformers** include: dry-type, dielectric liquid-filled, isolation, step-down, step-up, auto, wye, delta

**winding configurations** include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag, Scott connection

**low-voltage three-phase transformer components** include: ventilation fans, casings and enclosures, core, primary and secondary windings, bushings, on-line/off-line manual and automatic tap changers, dielectric liquid

## B-15.07 Installs high-voltage transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
B-15.07.01P	determine type of <b>high-voltage transformer</b> required and rating	type of <b>high-voltage transformer</b> meets criteria for operation
B-15.07.02P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
B-15.07.03P	determine protection devices	type and rating of protection devices are determined according to calculations, manufacturers' specifications and CEC requirements
B-15.07.04P	select tools and equipment	tools and equipment are selected according to task
B-15.07.05P	install protection devices	protection devices are installed according to manufacturers' specifications and CEC requirements
B-15.07.06P	remove existing <b>high-voltage transformer</b> prior to upgrade	existing <b>high-voltage transformer</b> is removed with minimal impact to surrounding equipment and interruption to operation
B-15.07.07P	position and mount <b>high-voltage transformer</b>	<b>high-voltage transformer</b> is positioned and mounted according to application, and AHJ, CSA and CEC requirements
B-15.07.08P	connect <b>high-voltage transformer</b>	<b>high-voltage transformer</b> is connected according to CEC and <b>system requirements</b>
B-15.07.09P	select and change tap settings of <b>high-voltage transformer</b>	tap settings of <b>high-voltage transformers</b> are selected and changed such that output voltage meets application requirements
B-15.07.10P	terminate high-voltage conductors	high-voltage conductors are terminated according to application, manufacturers' specifications and CEC requirements
B-15.07.11P	ground and bond <b>high-voltage transformer</b>	<b>high-voltage transformer</b> is grounded and bonded according to CEC requirements
B-15.07.12P	conduct <b>tests</b> of <b>high-voltage transformer</b>	<b>high-voltage transformer</b> is tested after installation, connected and functions according to application, drawings and manufacturers' specifications, and results documented

B-15.07.13P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.07.14P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.07.15P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**high-voltage transformers** include: dielectric liquid-filled, dry

**system requirements** include: input/output voltage, polarities, kVA ratings, conductor size, overcurrent protection, impedance, power factor, BIL ratings

**tests** include: insulation test, voltage test, hi-pot test, oil analysis test, turn ratio test, thermographic test

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

Knowledge		
	Learning Outcomes	Learning Objectives
B-15.07.01L	demonstrate knowledge of <b>high-voltage transformers</b> and <b>high-voltage transformer components</b> , their characteristics, applications and operation	identify types of <b>high-voltage transformers</b> , and describe their characteristics, applications and operation
		identify terminology associated with <b>high-voltage transformers</b>
		interpret codes and regulations pertaining to <b>high-voltage transformers</b>
		identify <b>winding configurations</b> for <b>high-voltage transformers</b>
		identify <b>high-voltage transformer components</b> , and describe their characteristics and applications
		interpret information contained on high-voltage transformer nameplates
		explain <b>high-voltage transformer</b> polarity and terminal markings
		identify considerations and requirements for selecting <b>high-voltage transformers</b>
B-15.07.02L	demonstrate knowledge of procedures to install <b>high-voltage transformers</b>	identify tools and equipment used to install <b>high-voltage transformers</b> , and describe their applications and procedures for use
		describe procedures to install <b>high-voltage transformers</b>

## Range of Variables

**high-voltage transformers** include: dielectric liquid-filled, dry

**winding configurations** include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag, Scott connection

**high-voltage transformer components** include: oil pumps, ventilation fans, casings and enclosures, core, primary and secondary windings, desiccant breather, bushings, dielectric liquid, indicators (pressure gauges, level gauges, temperature gauges), pressure relief devices, nameplate data, online monitoring systems, on-line/off-line manual and automatic tap changers, phase indicators, cooling fans, conservator tank

### B-15.08 Maintains high-voltage transformers

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

Performance Criteria		Evidence of Attainment
B-15.08.01P	determine maintenance requirements	maintenance requirements are determined according to maintenance schedule and manufacturers' specifications
B-15.08.02P	conduct tests	tests are conducted according to established maintenance schedule and manufacturers' specifications using <b>diagnostic and test equipment</b> , and results documented
B-15.08.03P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.08.04P	<b>clean and adjust</b> components	components are <b>cleaned and adjusted</b> , and high-voltage transformers are restored to optimal conditions according to manufacturers' specifications
B-15.08.05P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
B-15.08.06P	remove and dispose of or recycle unserviceable components	unserviceable components are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
B-15.08.07P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
B-15.08.08P	select tools and equipment	tools and equipment are selected according to task

B-15.08.09P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
B-15.08.10P	inspect high-voltage cables	high-voltage cables are inspected for irregularities
B-15.08.11P	select and install replacement high-voltage transformer components	equivalent replacement high-voltage transformer components match application and are installed with minimal disruptions and interruptions, and according to CEC requirements and manufacturers' specifications
B-15.08.12P	repair malfunctioning high-voltage transformer components	repaired high-voltage transformer components are operational
B-15.08.13P	update <b>documentation</b>	<b>documentation</b> reflects operational changes and maintenance history

## Range of Variables

**diagnostic and test equipment** includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, insulation resistance testers, ground loop tester, proximity tester

**cleaning and adjustment procedures** include: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, external metal case (including external latching system to prevent contamination and access), cleaning insulators

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections, oil sampling

**documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

## Knowledge

	Learning Outcomes	Learning Objectives
B-15.08.01L	demonstrate knowledge of <b>high-voltage transformers</b> and <b>high-voltage transformer components</b> , their characteristics, applications and operation	identify types of <b>high-voltage transformers</b> , and describe their characteristics, applications and operation
		identify <b>winding configurations</b> for <b>high-voltage transformers</b>
		identify high-voltage conductors, and describe their characteristics and application
		interpret codes and regulations pertaining to <b>high-voltage transformers</b>
		identify <b>high-voltage transformer components</b> , and describe their characteristics and applications

		interpret information contained on high-voltage transformers nameplates
		explain <b>high-voltage transformer</b> polarity and terminal markings
		identify considerations and requirements for selecting <b>high-voltage transformers</b>
B-15.08.02L	demonstrate knowledge of procedures to maintain <b>high-voltage transformers</b>	identify tools and equipment used to maintain <b>high-voltage transformers</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>high-voltage transformers</b>

## Range of Variables

**high-voltage transformers** are: dielectric liquid-filled, dry

**winding configurations** include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag, Scott connection

**high-voltage transformer components** include: oil pumps, ventilation fans, casings and enclosures, core, primary and secondary windings, desiccant breather, bushings, dielectric liquid, indicators (pressure gauges, level gauges, temperature gauges), pressure relief devices, nameplate data, online monitoring systems, on-line/off-line manual and automatic tap changers, phase indicators, cooling fans, conservator tank

# Major Work Activity C

## Installs and maintains wiring systems

### Task C-16 Installs and maintains raceways, cables, conductors and enclosures

#### Task Descriptor

Raceways contain and protect conductors and cables. Enclosures may be used to access and terminate the content of the raceway, and to facilitate the installation of conductors and the interconnection of components. Enclosures in this task do not include types for specific active electrical control equipment such as rotating equipment, transformers, panelboards, motor starters and other fixed control equipment.

Raceways and cables are installed in various environments. Industrial electricians install, and maintain raceways, cables and conductors.

It is understood that conduits and tubing are raceways, however for the purpose of this standard, raceways are separated from conduits and tubing to identify the different skills needed to install and maintain them.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

#### C-16.01 Installs conductors and cables

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
C-16.01.01P	determine <b>installation requirements</b> , and select conductors, cables and <b>components</b>	size, type and number of conductors, cables and <b>components</b> are selected, identified and colour-coded according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.02P	select tools and equipment	tools and equipment are selected according to task
C-16.01.03P	measure and cut conductors and cables	cables and conductors are measured and cut to allow for final routing and sufficient length for terminations according to CEC requirements

C-16.01.04P	install conductors, cables and <b>components</b>	conductors, cables and <b>components</b> are installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.05P	assemble <b>components</b>	<b>components</b> are assembled and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.06P	prepare conductors and cables for termination	conductors and cables are cleaned and prepared for termination according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.08P	complete documentation to reflect changes	all changes to new and updated installations are documented
C-16.01.09P	determine requirements for removal of existing conductors, cables and <b>components</b>	removal of existing conductors, cables and <b>components</b> requirements are determined according to facility requirements and considering impact removal will have on facility
C-16.01.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
C-16.01.11P	remove conductors, cables, and <b>components</b> , and update documentation	conductors, cables, and <b>components</b> are removed according to electrical specifications and AHJ requirements, and remaining installations are supported, terminated and left in a safe and secure state according to CSA and CEC requirements, and documentation updated

## Range of Variables

**installation requirements** include: purpose of cable or conductor, tools and equipment required for installation, installation environment in locations such as hazardous, wet, underground (direct buried or in raceway), outdoor, classes, categories, zones (divisions), type of termination

**components** include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds, non-ferrous and/or non-conductive plates, connectors

## Knowledge

	Learning Outcomes	Learning Objectives
C-16.01.01L	demonstrate knowledge of conductors, cables and their <b>components</b>	<p>identify terminology associated with conductors, cables and their <b>components</b></p> <p>identify types of conductors, cables and their <b>components</b>, and describe their characteristics and applications</p>



		interpret codes, standards and regulations pertaining to conductors and cables
		interpret information pertaining to conductors and cables found on drawings and specifications
		identify considerations and requirements for selecting conductors, cables and their <b>components</b>
		identify considerations and requirements for removal of conductors, cables and their <b>components</b>
C-16.01.02L	demonstrate knowledge of procedures to remove and install conductors, cables and their <b>components</b>	identify tools and equipment used to remove and install conductors, cables and their <b>components</b> , and describe their applications and procedures for use
		describe procedures to remove conductors, cables and their <b>components</b>
		describe procedures to prepare and install conductors, cables and their <b>components</b>
		describe procedures to terminate conductors and cables

## Range of Variables

**components** include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compound, non-ferrous and/or non-conductive plates, connectors

## C-16.02 Maintains conductors and cables

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-16.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
C-16.02.02P	select tools and equipment	tools and equipment are selected according to task
C-16.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
C-16.02.04P	determine type and location of fault	type and location of fault is determined according to <b>field assessments</b>

C-16.02.05P	repair or replace malfunctioning <b>component</b>	malfunctioning <b>component</b> is repaired or replaced and tested, and system is returned to original condition
C-16.02.06P	label repaired conductors and corresponding terminals	repaired conductors and corresponding terminals are labelled according to drawings and specifications
C-16.02.07P	inspect terminations and test conductors for excessive heating	terminations are inspected according to manufacturers' specifications and test results documented

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections, hi-pot test

**diagnostic and test equipment** includes: megohmmeters, multimeters, thermographic imaging devices, cable locators, hi-pot testers

**components** include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds, non-ferrous and/or non-conductive plates, connectors

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
C-16.02.01L	demonstrate knowledge of conductors, cables and their <b>components</b>	<p>identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause faults in specific types of conductors, cables and their <b>components</b></p> <p>interpret information pertaining to conductors and cables found on manufacturers' specifications and previous records</p> <p>interpret codes, standards and regulations pertaining to conductors and cables</p> <p>identify <b>considerations</b> when maintaining conductors, cables and their <b>components</b></p>
C-16.02.02L	demonstrate knowledge of procedures to maintain conductors, cables and their <b>components</b>	<p>identify tools and equipment used to maintain conductors, cables and their <b>components</b>, and describe their applications and procedures for use</p> <p>describe <b>procedures</b> to maintain conductors, cables and their <b>components</b></p>

## Range of Variables

**components** include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds, non-ferrous and/or non-conductive plates, connectors

**considerations** include: integrity of insulation, integrity of terminations, odours, colour, physical protection, supports, movement due to temperature or vibration

**procedures** include: thermographic surveys, multimeter testing, megohmmeter testing (resistance testing), hi-pot testing, sensory testing (visual, smell and touch)

### C-16.03 Installs conduit, tubing and fittings

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
C-16.03.01P	determine <b>installation requirements</b> , and select conduit, tubing and fittings	size and <b>type</b> of conduit, tubing and fittings are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.02P	determine routing of conduit and tubing	routing of conduit and tubing is practical for application and takes into consideration other trades and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.03P	select <b>tools and equipment</b>	<b>tools and equipment</b> are selected according to task
C-16.03.04P	measure, cut, thread and bend conduit and tubing	conduit and tubing are measured, cut, threaded and bent according to routing, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.05P	assemble, position, mount and support conduit, tubing and fittings	conduit, tubing and fittings are assembled, positioned, mounted and supported without damage, and according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.06P	determine requirements for removal of existing conduit, tubing and fittings	removal requirements are determined according to facility requirements and considering impact removal will have on facility
C-16.03.07P	remove conduit, tubing and fittings, and update documentation	conduit, tubing and fittings are removed, and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

## Range of Variables

**installation requirements** include: purpose of conduit, tubing and fitting, tools and equipment required for installation, installation environment in locations such as hazardous, wet, underground, outdoor, classes, categories and zones (divisions), combustible and non-combustible installations

**types** include: rigid metal, rigid Poly Vinyl Chloride (PVC), high-density polyethylene (HDPE) conduit, electrical metallic tubing (EMT), liquid-tight flex, coated rigid metal, non-metallic flex

**tools and equipment** include: PVC benders, PVC cutters, heat guns, pipe benders, pipe threading machines, power pipe benders, equipment for specialized conduit systems

Knowledge		
	Learning Outcomes	Learning Objectives
C-16.03.01L	demonstrate knowledge of conduit, tubing, <b> fittings and components</b> , their characteristics and applications	identify types of conduit, tubing, <b> fittings and components</b> , and describe their characteristics, applications and limitations
		interpret information pertaining to conduit, tubing, <b> fittings and components</b> found on drawings and specifications
		interpret codes and regulations pertaining to conduit, tubing, <b> fittings and components</b>
		identify considerations and requirements for removal of conduit, tubing, <b> fittings and components</b>
		identify considerations of other trades within same project
C-16.03.02L	demonstrate knowledge of procedures to remove and install conduit, tubing, <b> fittings and components</b>	identify <b> tools and equipment</b> used to remove and install conduit, tubing, <b> fittings and components</b> , and describe their applications and procedures for use
		describe procedures to cut, thread and bend conduit and tubing
		describe procedures to install and support conduit, tubing, <b> fittings and components</b>
		describe procedures used for removal of conduit, tubing, <b> fittings and components</b>

## Range of Variables

**fittings and components** include: mechanical fittings, rain-tight fittings, EYS, supports, straps, connectors, couplings, reducers, bushings, LB, LR, LL, Tee, close nipple, chase nipple, terminal adapters, offset, 90 degrees, 45 degrees, long and short sweeps, PVC cement, expansion joints, lock nuts, unions

**tools and equipment** include: PVC benders, PVC cutters, heat guns, pipe benders, pipe threading machines, power pipe benders, equipment for specialized conduit systems

## C-16.04 Installs raceways

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-16.04.01P	determine <b>installation requirements</b> and select raceways	size and type of <b>raceway</b> are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.02P	determine routing of <b>raceway</b>	routing of <b>raceway</b> is practical for application and takes into consideration other trades and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.03P	select tools and equipment	tools and equipment are selected according to task
C-16.04.04P	measure and cut <b>raceways</b> , and select fittings	<b>raceways</b> are measured and cut, and fittings are selected according to routing, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.05P	assemble <b>raceways</b> and fittings into position, and mount and support <b>raceways</b>	<b>raceways</b> and fittings are assembled into position, and <b>raceways</b> are mounted and supported without damage and according to application, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.06P	determine requirements for removal of existing <b>raceways</b>	removal requirements when performing an upgrade are determined according to facility requirements, and considering impact removal will have on facility
C-16.04.07P	remove <b>raceways</b> and <b>raceway components</b> and update documentation	<b>raceways</b> and <b>raceway components</b> are removed according to electrical specifications and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

## Range of Variables

**installation requirements** include: purpose of raceway, bonding of raceway, tools and equipment required for installation, installation environment in locations such as hazardous, wet, outdoor, classes, categories and zones (divisions)

**raceways** include: cable tray, ladder tray, wire trays, underfloor raceways, busways, cellular raceways, surface raceways

**raceways** do not include: conduit and tubing as these are covered in sub-task 16.03

**raceway components** include: fittings (couplings and connectors), supports, expansion joints, floor/junction boxes

Knowledge		
	Learning Outcomes	Learning Objectives
C-16.04.01L	demonstrate knowledge of <b>raceways</b> , <b>raceway components</b> , their characteristics and applications	identify types of <b>raceways</b> and <b>raceway components</b> , and describe their characteristics, applications and limitations
		interpret codes, standards and regulations pertaining to <b>raceways</b>
		interpret information pertaining to <b>raceways</b> found on drawings and specifications
		identify considerations and requirements for selecting <b>raceways</b> and <b>raceway components</b>
		identify considerations and requirements for removal of <b>raceways</b> and <b>raceway components</b>
C-16.04.02L	demonstrate knowledge of procedures to remove, install and support <b>raceways</b>	identify considerations of other trades within same project
		identify tools and equipment used to remove, install and support <b>raceways</b> , and describe their applications and procedures for use
		describe procedures to install and support <b>raceways</b> and <b>raceway components</b>
		describe procedures to remove <b>raceways</b> and <b>raceway components</b>

## Range of Variables

**raceways** in this sub-task include: cable tray, ladder tray, wire trays, underfloor raceways, busways, cellular raceways, surface raceways

**raceways** in this sub-task do not include: conduit and tubing as these are covered in sub-task 16.03

**raceway components** include: fittings (couplings and connectors), supports, expansion joints, floor/junction boxes

## C-16.05 Installs boxes and enclosures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-16.05.01P	determine <b>installation requirements</b> and select boxes and <b>enclosures</b>	size and type of boxes and <b>enclosures</b> are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.02P	determine installation location for boxes and <b>enclosures</b>	location for box and <b>enclosures</b> is practical for application, takes into consideration other trades, and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.03P	select tools and equipment	tools and equipment are selected according to task
C-16.05.04P	position and mount boxes and <b>enclosures</b>	boxes and <b>enclosures</b> are positioned and mounted without damage to meet requirements of application and according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.05P	determine requirements for removal of existing boxes and <b>enclosures</b>	removal requirements for existing boxes and <b>enclosures</b> are determined according to facility requirements and considering impact removal will have on facility
C-16.05.06P	remove boxes and <b>enclosures</b> and update documentation	boxes and <b>enclosures</b> are removed and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

### Range of Variables

**installation requirements** include: purpose of box or enclosure, mass/weight of equipment, tools and equipment required for installation, installation environment in locations such as hazardous, wet, indoor/outdoor, classes, categories and zones (divisions)

**enclosures** do not include: enclosure types for specific active electrical control equipment such as rotating equipment, transformers, panelboards, motor starters and other fixed control equipment

## Knowledge

Learning Outcomes	Learning Objectives
C-16.05.01L demonstrate knowledge of boxes and <b>enclosures</b> , their characteristics and applications	identify types of boxes and <b>enclosures</b> , and describe their characteristics, applications and limitations
	interpret codes, standards and regulations pertaining to boxes and <b>enclosures</b>
	interpret information pertaining to boxes and <b>enclosures</b> found on drawings and specifications
	identify <b>considerations</b> and requirements for selecting boxes and <b>enclosures</b>
	identify <b>considerations</b> and requirements for removal of boxes and <b>enclosures</b>
C-16.05.02L demonstrate knowledge of procedures to maintain <b>enclosures</b>	identify <b>considerations</b> of other trades within same project
	identify tools and equipment used to maintain <b>enclosures</b> , and describe their applications and procedures for use
	describe procedures to determine placement and to mount boxes and <b>enclosures</b>
	describe procedures to remove boxes and <b>enclosures</b>

### Range of Variables

**enclosures** do not include: enclosure types for specific active electrical control equipment such as rotating equipment, transformers, panelboards, motor starters and other fixed control equipment

**considerations** include: materials, volume, dimensions, positioning, mass/weight, environment, accessibility, size of raceway or cable entering box or enclosure, CSA types (NEMA), Ingress Protection (IP) types



## C-16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
C-16.06.01P	conduct <i>inspections</i>	<i>inspections</i> of conduit, tubing, fittings, raceways, boxes, enclosures and associated <i>components</i> are completed, and results documented
C-16.06.02P	select tools and equipment	tools and equipment are selected according to task
C-16.06.03P	clean conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>	conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i> are cleaned according to housekeeping standards, and facility and AHJ requirements
C-16.06.04P	locate and determine type of malfunction	location and type of malfunction is identified according to <i>inspections</i>
C-16.06.05P	repair or replace damaged conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>	damaged conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i> are repaired or replaced according to AHJ, CSA and CEC requirements
C-16.06.06P	tighten or adjust loose <i>components</i>	<i>components</i> are tightened or adjusted according to AHJ, CSA and CEC requirements

### Range of Variables

*inspections* include: visual (internal and external), physical inspections

*components* include: supports, expansion joints, straps, connectors, couplings, screws, bolts

### Knowledge

Learning Outcomes		Learning Objectives
C-16.06.01L	demonstrate knowledge of conduit, tubing, fittings, raceways, boxes, and their <i>components</i>	<p>identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause damage in specific types of conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i></p> <p>interpret codes, standards and regulations pertaining to conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i></p>

		identify <b>considerations</b> when maintaining conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b>
C-16.06.02L	demonstrate knowledge of procedures to maintain conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b>	identify tools and equipment used to maintain conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b> , and describe their applications and procedures for use
		describe procedures to repair or replace conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b>
		describe procedures to tighten or adjust conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b>
		describe procedures to clean conduit, tubing, fittings, raceways, boxes, enclosures and their <b>components</b>

### Range of Variables

**components** include: supports, expansion joints, straps, connectors, couplings, screws, bolts, locknuts

**considerations** include: corrosion, condition of supports, tightness and presence of mounting screws, tightness of locknuts, physical damage, cleanliness

## Task C-17 Installs and maintains branch circuitry and devices

### Task Descriptor

Various devices and luminaires are installed to meet the power and lighting requirements of the facility sources. Branch circuitry components are installed in a manner which makes the power safe and convenient to use. Branch circuitry is used to conduct the power from the overcurrent device to the load. Lighting systems are used to illuminate specified areas according to consumer needs. Lighting controls operate light functions, adjust lighting levels and optimize efficiency. Industrial electricians install and maintain branch circuitry.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### C-17.01 Installs luminaires

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
C-17.01.01P	determine type of <b>luminaire installation requirements</b>	size and type of <b>luminaire</b> are selected for application according to job, facility and CEC requirements
C-17.01.02P	determine type of <b>lamps</b> and <b>installation requirements</b>	size and type of <b>lamps</b> are selected for application according to manufacturers' specifications and facility requirements
C-17.01.03P	calculate branch circuit requirements	calculations are completed based on voltage and amperage requirements and according to CEC requirements
C-17.01.04P	determine installation location for <b>luminaire</b>	<b>luminaire</b> locations are determined according to drawings, specifications, facility requirements, codes and design criteria for luminaire
C-17.01.05P	select tools and equipment	tools and equipment are selected according to task
C-17.01.06P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and CEC requirements
C-17.01.07P	mount <b>luminaire</b>	<b>luminaire</b> is mounted and supported according to drawings, specifications, facility and CEC requirements, and other codes

C-17.01.08P	install branch circuit wiring	branch circuit wiring is installed and identified according to drawings, specifications and CEC requirements, and without damage to insulation and without stress
C-17.01.09P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-17.01.10P	test for required operation	operation is verified by testing operation and lighting levels
C-17.01.11P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
C-17.01.12P	determine requirements for removal of <b>luminaires</b>	requirements for removal of <b>luminaires</b> are determined according to facility requirements and considering impact removal will have on facility
C-17.01.13P	remove existing <b>luminaires</b>	existing <b>luminaires</b> are removed and remaining installations are left in a safe condition according to facility, AHJ, CSA and CEC requirements
C-17.01.14P	update documentation	documentation is updated to reflect changes
C-17.01.15P	dispose of or recycle <b>lamps</b> , ballasts, and enclosures	<b>lamps</b> , ballasts and enclosures are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements

## Range of Variables

**luminaires** include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed

**lamps** include: high intensity discharge (HID), light emitting diode (LED), incandescent, fluorescent, ultraviolet, infrared

**installation requirements** include: purpose of luminaire, tools and equipment required for installation, lighting controls, seismic requirements, installation environment in locations (hazardous, wet), indoor/outdoor, classes, zones (divisions), categories

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
C-17.01.01L	demonstrate knowledge of <b>luminaires</b> and <b>lamps</b> , their characteristics, applications and operation	identify types of <b>luminaires</b> and <b>lamps</b> , and describe their characteristics, applications and operation
		identify luminaire and lamp components, and describe their characteristics and applications
		interpret codes, standards and regulations pertaining to <b>luminaires</b> and <b>lamps</b>

		interpret information pertaining to <b>luminaires</b> and <b>lamps</b> found on drawings and specifications
		identify considerations and requirements for removal of <b>luminaires</b> , <b>lamps</b> and their components
		identify considerations and requirements for selecting <b>luminaires</b> and <b>lamps</b> , and their components
C-17.01.02L	demonstrate knowledge of procedures to remove, install, dispose of or recycle and support <b>luminaires</b> and <b>lamps</b>	identify tools and equipment used to remove, install, dispose of or recycle and support <b>luminaires</b> and <b>lamps</b> , and describe their applications and procedures for use
		describe procedures to remove <b>luminaires</b> and <b>lamps</b> , and their components
		describe procedures to retrofit <b>luminaires</b> and their components
		describe procedures to install and support <b>luminaires</b> and their components
		describe procedures to perform tests related to <b>luminaires</b> and <b>lamps</b>
		describe procedures for disposal of or recycling of <b>luminaires</b> and <b>lamps</b> , and their components

## Range of Variables

**luminaires** include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed

**lamps** include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

## C-17.02 Maintains luminaires

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
C-17.02.01P	clean <b>luminaires</b> and <b>lamps</b>	<b>luminaires</b> and <b>lamps</b> are cleaned according to facility requirements and environmental conditions
C-17.02.02P	select tools and equipment	tools and equipment are selected according to task

C-17.02.03P	determine source of malfunction	source of malfunction is determined according to <b>facility sources</b> observation or complaint, <b>field assessments</b> , and <b>diagnostic and test equipment</b> results
C-17.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
C-17.02.05P	select replacement components	OEM or equivalent replacement components are selected
C-17.02.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions
C-17.02.07P	conduct tests of branch circuitry, <b>luminaires</b> and <b>lamps</b>	branch circuitry, <b>luminaires</b> and <b>lamps</b> are tested after repair and scheduled maintenance, connected and function according to manufacturers' specifications and codes
C-17.02.08P	update documentation	documentation is updated to reflect changes

## Range of Variables

**luminaires** include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed

**lamps** include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, fluorescent light tester, light intensity meters

## Knowledge

	Learning Outcomes	Learning Objectives
C-17.02.01L	demonstrate knowledge of branch circuitry, <b>luminaires</b> and <b>lamps</b> , their components, characteristics, applications and operation	identify types of branch circuitry, <b>luminaires</b> and <b>lamps</b> , and their components, and describe their characteristics, applications and operation
C-17.02.02L	demonstrate knowledge of procedures to maintain branch circuitry, <b>luminaires</b> and <b>lamps</b> , and their components	identify tools and equipment used to maintain branch circuitry, <b>luminaires</b> and <b>lamps</b> , and their components, and describe their applications and procedures for use
		describe procedures to maintain branch circuitry, <b>luminaires</b> and <b>lamps</b> , and their components

## Range of Variables

**luminaires** include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed

**lamps** include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

### C-17.03 Installs wiring devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-17.03.01P	determine type of <b>wiring devices</b> required and <b>installation requirements</b>	type of <b>wiring devices</b> and their <b>installation requirements</b> are selected according to drawings, specifications, and CEC and facility requirements
C-17.03.02P	determine installation location for <b>wiring devices</b>	<b>wiring devices</b> locations are determined according to drawings, specifications, and CEC and facility requirements
C-17.03.03P	select tools and equipment	tools and equipment are selected according to task
C-17.03.04P	select <b>wiring devices</b>	<b>wiring devices</b> are selected according to drawings, specifications and CEC requirements
C-17.03.05P	install wiring	wiring is installed and identified according to drawings, specifications and CEC requirements, and without damage to insulation and without stress
C-17.03.06P	mount <b>wiring devices</b>	<b>wiring devices</b> are mounted according to manufacturers' specifications and CEC requirements
C-17.03.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ and CEC requirements
C-17.03.08P	test for required operation	operation is verified by testing circuit for specified voltage and phasing
C-17.03.09P	select and install cover plate	cover plate is selected and installed according to facility requirements and codes
C-17.03.10P	determine requirements for removal of <b>wiring devices</b>	removal requirements are determined according to facility requirements and considering impact removal will have on facility

C-17.03.11P	remove existing <b>wiring devices</b>	<b>wiring devices</b> are removed and remaining installations are left in a safe condition according to AHJ and CEC requirements
C-17.03.12P	update documentation	documentation is updated to reflect changes

## Range of Variables

**wiring devices** include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles

**installation requirements** include: purpose of wiring device, tools and equipment required for installation, device controls, seismic requirements, installation environment in locations (hazardous, wet), indoor/outdoor, classes, categories and zones (divisions)

Knowledge		
	Learning Outcomes	Learning Objectives
C-17.03.01L	demonstrate knowledge of <b>wiring devices</b> , their characteristics, applications and operation	identify types of <b>wiring devices</b> , and describe their characteristics, applications and operation
		interpret codes, standards and regulations pertaining to <b>wiring devices</b>
		interpret information pertaining to <b>wiring devices</b> found on drawings and specifications
		identify considerations and requirements for removal of <b>wiring devices</b>
		identify considerations and requirements for selecting <b>wiring devices</b>
C-17.03.02L	demonstrate knowledge of procedures to remove and install <b>wiring devices</b>	identify tools and equipment used to remove and install <b>wiring devices</b> , and describe their applications and procedures for use
		describe procedures to remove and install <b>wiring devices</b>

## Range of Variables

**wiring devices** include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles



## C-17.04 Maintains wiring devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
C-17.04.01P	determine source of malfunction	source of malfunction is determined according to <b>facility sources</b> , <b>field assessments</b> , and <b>diagnostic and test equipment</b> results
C-17.04.02P	select tools and equipment	tools and equipment are selected according to task
C-17.04.03P	identify and remove defective components	defective components are removed without damage to system or other components
C-17.04.04P	select replacement components	OEM or equivalent replacement components are selected
C-17.04.05P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions
C-17.04.06P	conduct tests of branch circuitry and <b>wiring devices</b>	branch circuitry and <b>wiring devices</b> are tested after repair, connected and function according to manufacturers' specifications and CEC requirements
C-17.04.07P	update documentation	documentation is updated to reflect changes

### Range of Variables

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices

**wiring devices** include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles

## Knowledge

	Learning Outcomes	Learning Objectives
C-17.04.01L	demonstrate knowledge of branch circuitry and <b>wiring devices</b> , their components, characteristics, applications and operation	identify types of branch circuitry and <b>wiring devices</b> , and their components, and describe their characteristics, applications and operation
C-17.04.02L	demonstrate knowledge of procedures to maintain branch circuitry and <b>wiring devices</b> , and their components	identify tools and equipment used to maintain branch circuitry and <b>wiring devices</b> , and their components, and describe their applications and procedures for use
		describe procedures to maintain branch circuitry and <b>wiring devices</b> , and their components

### Range of Variables

**wiring devices** include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles

## Task C-18 Installs and maintains heating, ventilation and air-conditioning (HVAC) electrical components

### Task Descriptor

Heating, ventilation and cooling systems (in this task, that is, systems where electricity is not the sole source of energy) are typically installed by other trades but are electrically connected by industrial electricians. Industrial electricians connect power to HVAC systems, HVAC associated equipment and controls. They also install HVAC system controls as well as repair or replace HVAC components, controls and associated equipment.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspections, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### C-18.01 Connects power to HVAC systems and associated equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-18.01.01P	determine connected load requirements	connected load requirements are determined by interpreting nameplate ratings, and according to drawings, specifications, and AHJ, CSA and CEC requirements
C-18.01.02P	select feeder or branch circuit wiring, disconnect means and overcurrent protection devices	feeders or branch circuit wiring, disconnect means and overcurrent protection devices are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-18.01.03P	select tools and equipment	tools and equipment are selected according to task
C-18.01.04P	install feeder or branch circuit wiring,	branch circuit wiring conductors, are identified, selected and installed without damage to insulation and without stress according to drawings, specifications, and CEC requirements
C-18.01.05P	install disconnect means and overcurrent protection devices	disconnect means and overcurrent protection devices are identified, selected and installed according to drawings, specifications, and CEC requirements

C-18.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements
C-18.01.07P	test operation	operation is verified by testing circuit for specified voltage, amperage and rotation according to AHJ
C-18.01.08P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**HVAC systems and associated equipment** include: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

Knowledge		
	Learning Outcomes	Learning Objectives
C-18.01.01L	demonstrate knowledge of <b>HVAC systems and associated equipment</b> , their characteristics, applications and operation	identify terminology associated with <b>HVAC systems and associated equipment</b> , and their controls
		identify types of <b>HVAC systems and associated equipment</b> , and describe their characteristics, applications and operation
		interpret information pertaining to <b>HVAC systems and associated equipment</b> found on drawings, specifications and nameplates
		interpret codes, standards and regulations pertaining to electrical components of <b>HVAC systems and associated equipment</b>
		identify considerations and requirements for connecting <b>HVAC systems and associated equipment</b>
C-18.01.02L	demonstrate knowledge of procedures to connect <b>HVAC systems and associated equipment</b>	identify tools and equipment used to connect <b>HVAC systems and associated equipment</b> , and describe their applications and procedures for use
		describe procedures to connect <b>HVAC systems and associated equipment</b>

## Range of Variables

**HVAC systems and associated equipment** include: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

## C-18.02 Installs HVAC controls

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
C-18.02.01P	select tools and equipment	tools and equipment are selected according to task
C-18.02.02P	calculate circuitry and load requirements	calculations are completed based on voltage and amperage requirements, specifications and CEC requirements
C-18.02.03P	install control circuit wiring	control circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-18.02.04P	assemble and install <b>auxiliary control components</b>	<b>auxiliary control components</b> are assembled and installed according to manufacturers' specifications and CEC requirements
C-18.02.05P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements
C-18.02.06P	program and test HVAC controls	program is verified by operation of HVAC controls according to specifications, facility and AHJ requirements, and commissioning procedures
C-18.02.07P	document test results	test results are documented
C-18.02.08P	determine requirements for isolation and removal of existing HVAC controls when performing an upgrade	isolation and removal requirements of existing HVAC controls when performing an upgrade are determined according to environmental regulations, facility requirements and considering impact removal will have on facility
C-18.02.09P	update documentation	documentation is updated to reflect changes carried out

### Range of Variables

**auxiliary control components** include: time clocks, relays, sensors, thermostats, actuators, electrical interlocks, multiple function controllers, variable frequency drive (VFD), reduced voltage (soft) starters, discrete and analog devices

## Knowledge

	Learning Outcomes	Learning Objectives
C-18.02.01L	demonstrate knowledge of HVAC and <b>auxiliary control components</b> , their characteristics, applications and operation	identify types of HVAC and <b>auxiliary control components</b> , and describe their characteristics, applications and operation
		interpret information pertaining to HVAC and <b>auxiliary control components</b> found on drawings and specifications
		interpret codes and regulations pertaining to HVAC and <b>auxiliary control components</b>
		identify considerations and requirements for removal of HVAC and <b>auxiliary control components</b>
		identify considerations and requirements for selecting HVAC and <b>auxiliary control components</b>
C-18.02.02L	demonstrate knowledge of procedures to install or replace, connect and test HVAC and <b>auxiliary control components</b>	identify tools and equipment used to install or replace, connect and test HVAC and <b>auxiliary control components</b> , and describe their applications and procedures for use
		describe procedures to isolate and remove HVAC and <b>auxiliary control components</b>
		describe procedures to install HVAC and <b>auxiliary control components</b>
		describe procedures to connect HVAC and <b>auxiliary control components</b>
		describe procedures to test HVAC and <b>auxiliary control components</b>

### Range of Variables

**auxiliary control components** include: time clocks, relays, sensors, thermostats, actuators, electrical interlocks, multiple function controllers, VFD, reduced voltage (soft) starters, discrete and analog devices

## C-18.03 Maintains HVAC electrical components

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-18.03.01P	select tools and equipment	tools and equipment are selected according to task
C-18.03.02P	verify operation of <b>HVAC electrical components</b>	<b>HVAC electrical components</b> are verified according to manufacturers' specifications and operational requirements by conducting <b>field assessments</b> using <b>diagnostic and test equipment</b>
C-18.03.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
C-18.03.04P	identify and remove defective <b>HVAC electrical components</b>	defective <b>HVAC electrical components</b> are removed without damage to system or other components
C-18.03.05P	repair malfunctioning <b>HVAC electrical components</b>	repaired <b>HVAC electrical components</b> and equipment are operational
C-18.03.06P	select replacement <b>HVAC electrical components</b>	OEM or equivalent replacement <b>HVAC electrical components</b> are selected
C-18.03.07P	install replacement <b>HVAC electrical components</b> and reprogram	OEM or equivalent replacement <b>HVAC electrical components</b> are installed with minimal disruptions and interruptions and are reprogrammed to parameters prior to replacement
C-18.03.08P	conduct tests of <b>HVAC electrical components</b>	<b>HVAC electrical components</b> are tested after repair, connected and function according to manufacturers' specifications and facility requirements, and system operation is verified
C-18.03.09P	document tests in maintenance schedule	operational problems are identified in maintenance schedule data

### Range of Variables

**HVAC electrical components** include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, reduced voltage (soft) starters, discrete and analog sensors

**field assessments** include: sensory inspections, technical inspections, vibration analysis

**diagnostic and test equipment** includes: multimeters, clamp-on ammeters, thermographic imaging devices, non-contact temperature sensor, vibration sensor and analyzer

## Knowledge

Learning Outcomes	Learning Objectives	
C-18.03.01L	demonstrate knowledge of complete <b><i>HVAC system and associated equipment</i></b> and individual <b><i>HVAC electrical components</i></b>	identify terminology associated with <b><i>HVAC system and associated equipment</i></b> , and individual <b><i>HVAC electrical components</i></b>
		identify types of <b><i>HVAC systems and associated equipment</i></b> , and describe their characteristics, applications and operation
C-18.03.02L	demonstrate knowledge of interaction between individual <b><i>HVAC electrical components</i></b> , and their effect on <b><i>HVAC system and associated equipment</i></b>	describe how operation or failure of an individual component impacts other components or complete system
C-18.03.03L	demonstrate knowledge of procedures to maintain <b><i>HVAC electrical components</i></b>	identify tools and equipment used to maintain <b><i>HVAC electrical components</i></b> , and describe their applications and procedures for use
		describe procedures to troubleshoot faults in <b><i>HVAC electrical components</i></b>
		describe procedures to repair and replace <b><i>HVAC electrical components</i></b>
		describe procedures to adjust and reprogram <b><i>HVAC electrical components</i></b>
		describe procedures to verify operation of repaired <b><i>HVAC electrical components</i></b>

### Range of Variables

***HVAC systems and associated equipment*** include: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

***HVAC electrical components*** include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, reduced voltage (soft) starters, discrete and analog sensors



## Task C-19 Installs and maintains electric heating systems and controls

### Task Descriptor

Electric heating systems and their associated control devices are sized, installed and connected by industrial electricians. For industrial electricians, electric heating systems include process and environmental heating.

Industrial electricians maintain electric heating systems and their associated controls by performing inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure electric heating systems and their associated control devices are in operating condition.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### C-19.01 Installs electric heating systems and controls

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-19.01.01P	determine type of <b>electric heating system</b> , and type and ratings of <b>controls</b> required	type of <b>electric heating system</b> is selected according to application, and type and rating of <b>controls</b> are selected according to system requirements
C-19.01.02P	determine size of <b>electric heating system</b> required	size of <b>electric heating system</b> is selected by referencing <b>heat loss calculations</b> and according to application and AHJ requirements
C-19.01.03P	select tools and equipment	tools and equipment are selected according to task
C-19.01.04P	determine branch circuit requirements	branch circuit requirements are determined according to CEC and AHJ requirements
C-19.01.05P	determine installation location for heating device	heating device locations are determined according to manufacturers' specifications, and facility, CEC and AHJ requirements
C-19.01.06P	select feeder and/or branch circuit wiring	feeder and/or branch circuit wiring is selected according to drawings, specifications, and facility and CEC requirements

C-19.01.07P	install feeder and/or branch circuit wiring	feeder and/or branch circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and CEC and AHJ requirements
C-19.01.08P	install electrical heating device	heating device is installed according to manufacturers' specifications and CEC requirements
C-19.01.09P	install <b>controls</b>	heating <b>controls</b> are installed based on existing systems, and according to manufacturers' specifications and CEC requirements
C-19.01.10P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and CEC and AHJ requirements
C-19.01.11P	test operation	operation is verified by testing circuit voltage, amperage and controls
C-19.01.12P	determine requirements for removal of <b>electric heating systems</b> and <b>controls</b>	removal requirements for <b>electric heating systems</b> and <b>controls</b> are determined according to environmental regulations, facility requirements, and considering impact removal will have on facility
C-19.01.13P	remove existing <b>electric heating systems</b> and <b>controls</b>	<b>electric heating systems</b> and <b>controls</b> are removed and remaining installations are left in a safe and secure state
C-19.01.14P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**electric heating systems** include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters

**controls** include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers, flow switches

**heat loss calculations** include: volume of space being heated, thermal properties of surrounding structure, inside design temperature, outside design temperature

## Knowledge

	Learning Outcomes	Learning Objectives
C-19.01.01L	demonstrate knowledge of <b>electric heating systems</b> and <b>controls</b> , their characteristics, applications and operation	identify terminology associated with <b>electric heating systems</b> and <b>controls</b>
		identify types of <b>electric heating systems</b> , and describe their applications and operation

		identify types of electric heating <b>controls</b> , and describe their applications and operation
		interpret codes, standards and regulations pertaining to sizing and installing <b>electric heating systems</b> and <b>controls</b>
		identify considerations and requirements for selecting <b>electric heating systems</b> and <b>controls</b> , and their components including existing controls and systems, service capacity, and heating application
		identify considerations and requirements for removal of <b>electric heating systems</b> and <b>controls</b> including safety and loss of heating capacity
C-19.01.02L	demonstrate knowledge of procedures to remove and install <b>electric heating systems</b> and <b>controls</b>	identify tools and equipment used to remove and install <b>electric heating systems</b> and <b>controls</b> , and describe their applications and procedures for use
		describe how <b>heat loss calculations</b> affect the sizing of equipment
		describe procedures to remove <b>electric heating systems</b> and <b>controls</b>
		describe procedures to install <b>electric heating systems</b> and <b>controls</b>

## Range of Variables

**electric heating systems** include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters

**controls** include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers, flow switches

**heat loss calculations** include: volume of space being heated, thermal properties of surrounding structure, inside design temperature, outside design temperature

## C-19.02 Maintains electric heating systems and controls

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-19.02.01P	select tools and equipment	tools and equipment are selected according to task
C-19.02.02P	verify operation of system	system equipment operation is verified according to manufacturers' specifications and operational requirements by using <b>field assessments</b> and <b>diagnostic and test equipment</b>
C-19.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
C-19.02.04P	identify and remove defective electric heating system components	defective electric heating system components are removed without damage to system or other components
C-19.02.05P	select replacement components	OEM or equivalent replacement components are selected
C-19.02.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions and according to manufacturers' specifications
C-19.02.07P	conduct tests of <b>electric heating systems</b> and <b>controls</b>	<b>electric heating systems</b> and <b>controls</b> are tested after repair, connected and function according to manufacturers' specifications and facility requirements, and system operation verified
C-19.02.08P	clean and adjust components	electric heating systems and controls components are restored to operating conditions
C-19.02.09P	update maintenance log	maintenance log is updated to reflect tasks performed

### Range of Variables

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, non-contact temperature sensors

**electric heating systems** include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters

**controls** include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers

## Knowledge

	Learning Outcomes	Learning Objectives
C-19.02.01L	demonstrate knowledge of <b>electric heating systems</b> and <b>controls</b> , their characteristics, applications and operation	identify terminology associated with <b>electric heating systems</b> and <b>controls</b>  identify types of <b>electric heating systems</b> , <b>controls</b> and their components, and describe their characteristics, applications and operation  describe operation of <b>electric heating system</b> and <b>controls</b>
C-19.02.02L	demonstrate knowledge of procedures to maintain <b>electric heating systems</b> and <b>controls</b>	identify tools and equipment used to maintain <b>electric heating systems</b> and <b>controls</b> , and describe their applications and procedures for use  describe procedures to troubleshoot faults in <b>electric heating systems</b> and <b>controls</b>  describe procedures to repair or replace <b>electric heating systems</b> and <b>controls</b>  describe procedures to verify operation of repaired <b>electrical heating systems</b> and <b>controls</b>

### Range of Variables

**electric heating systems** include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters

**controls** include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers

## Task C-20 Installs and maintains exit and emergency lighting systems

### Task Descriptor

Exit and emergency lighting systems are used to facilitate safe egress from buildings during emergency situations. The systems can be powered by back-up power supplies such as batteries or stand-by generators. The required size and placement are determined by AHJ and building codes. Industrial electricians install and maintain exit and emergency lighting systems.

Industrial electricians maintain exit and emergency lighting systems by performing inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure exit and emergency lighting systems are in operating condition. They also record all inspection and maintenance results according to AHJ.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### C-20.01 Installs exit and emergency lighting systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-20.01.01P	determine type, size, capacity and installation requirements of <b>exit and emergency lighting system</b> required	type, size, capacity and installation requirements of <b>exit and emergency lighting system</b> is determined according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.02P	calculate connected load	connected load is calculated considering voltage drop according to AHJ, CSA and CEC requirements
C-20.01.03P	determine branch circuit requirements and standby energy source	branch circuit requirements and standby energy source are determined according to AHJ, CSA and CEC requirements
C-20.01.04P	determine installation location for <b>exit and emergency lighting system</b>	exit and emergency lighting system locations are determined according to drawings, specifications and AHJ requirements
C-20.01.05P	select tools and equipment	tools and equipment are selected according to task
C-20.01.06P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and facility and CEC requirements

C-20.01.07P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation and without stress, and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.08P	install exit and emergency lighting devices	exit and emergency lighting devices are installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.09P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.10P	test operation	operation is verified by testing circuit for specified voltage, lighting levels and duration of operation
C-20.01.11P	complete documentation	test results are documented according to AHJ, CSA and CEC requirements
C-20.01.12P	determine requirements for removal of <b>exit and emergency lighting system</b>	removal requirements for <b>exit and emergency lighting system</b> are determined according to environmental regulations, facility requirements and considering impact removal will have on facility
C-20.01.13P	remove and dispose of or recycle existing <b>exit and emergency lighting system</b> and update documentation	<b>exit and emergency lighting system</b> is removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-20.01.14P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**exit and emergency lighting systems** include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs

### Knowledge

	Learning Outcomes	Learning Objectives
C-20.01.01L	demonstrate knowledge of <b>exit and emergency lighting systems</b> , their characteristics, applications and operation	<p>identify terminology associated with <b>exit and emergency lighting systems</b></p> <p>identify types of <b>exit and emergency lighting systems</b>, and describe their characteristics, applications and operation</p> <p>interpret information pertaining to <b>exit and emergency lighting systems</b> found on drawings and specifications</p>

		identify exit and emergency lighting system components, and describe their characteristics and applications
		interpret codes, standards and regulations pertaining to <b>exit and emergency lighting systems</b>
		identify considerations, calculations and requirements for selecting <b>exit and emergency lighting systems</b> and their components
		identify considerations and requirements for removal and disposal of <b>exit and emergency lighting systems</b> and their components
C-20.01.02L	demonstrate knowledge of procedures to remove and install <b>exit and emergency lighting systems</b> and their components	identify tools and equipment used to remove and install <b>exit and emergency lighting systems</b> and their components, and describe their applications and procedures for use
		describe procedures to remove <b>exit and emergency lighting systems</b> and their components
		describe procedure used to install <b>exit and emergency lighting systems</b> and their components
		describe procedures to test <b>exit and emergency lighting systems</b> and their components and complete documentation

### Range of Variables

**exit and emergency lighting systems** include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs



## C-20.02 Maintains exit and emergency lighting systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-20.02.01P	select tools and equipment	tools and equipment are selected according to task
C-20.02.02P	verify operation of equipment	equipment operation is verified according to manufacturers' specifications and operational requirements by using <b>field assessments</b> and <b>diagnostic and test equipment</b>
C-20.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
C-20.02.04P	identify, remove and dispose of or recycle defective components	defective components are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-20.02.05P	repair malfunctioning components	repaired components are operational
C-20.02.06P	select replacement components	OEM or equivalent replacement components are selected
C-20.02.07P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions according to manufacturers' specifications
C-20.02.08P	conduct tests of <b>exit and emergency lighting systems</b>	<b>exit and emergency lighting systems</b> are tested after repair, component replacement or as required by maintenance schedule, and are connected and function according to manufacturers' specifications, and AHJ, CSA and CEC requirements, and system operation verified
C-20.02.09P	document tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data

### Range of Variables

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeter, light intensity meters

**exit and emergency lighting systems** include: unit equipment, normal and standby (emergency) powered, remote lighting unit, automatic emergency power transfer control relays, associated wiring components and circuits, battery packs

## Knowledge

	Learning Outcomes	Learning Objectives
C-20.02.01L	demonstrate knowledge of <b><i>exit and emergency lighting systems</i></b> , their characteristics, applications and operation	identify terminology associated with <b><i>exit and emergency lighting systems</i></b>  identify types of <b><i>exit and emergency lighting systems</i></b> and describe their characteristics, applications and operation  identify exit and emergency lighting system components, and describe their applications and operation  describe requirements to record and document test results
C-20.02.02L	demonstrate knowledge of procedures to maintain <b><i>exit and emergency lighting systems</i></b> , and their components	identify tools and equipment used to maintain <b><i>exit and emergency lighting systems</i></b> , and their components, and describe their applications and procedures for use  describe procedures to maintain <b><i>exit and emergency lighting systems</i></b> , and their components

### Range of Variables

***exit and emergency lighting systems*** include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs

## Task C-21 Installs and maintains cathodic protection systems

### Task Descriptor

Cathodic protection systems refer to impressed DC current cathodic protection systems that introduce an electrical current onto a tank, pipe or structure to limit corrosion and oxidation. Industrial electricians install these systems in various environments according to specifications.

Industrial electricians maintain cathodic protection systems by performing visual inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure cathodic systems are in operating condition.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### C-21.01 Installs cathodic protection systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-21.01.01P	determine installation location for <b><i>cathodic protection system components</i></b>	<b><i>cathodic protection system components</i></b> installations are determined according to manufacturers’ specifications, and facility, AHJ, CSA and CEC requirements
C-21.01.02P	select branch circuit wiring	branch circuit wiring is selected according to manufacturers’ specifications and CEC requirements
C-21.01.03P	select tools and equipment	tools and equipment are selected according to task
C-21.01.04P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-21.01.05P	install <b><i>cathodic protection system components</i></b>	<b><i>cathodic protection system components</i></b> are installed according to manufacturers’ specifications, and AHJ, CSA and CEC requirements
C-21.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers’ specifications, and AHJ, CSA and CEC requirements

C-21.01.07P	test operation	operation is verified by testing circuit for specified requirements according to manufacturers' specifications
C-21.01.08P	determine requirements for removal of <b>cathodic protection system components</b>	removal requirements for <b>cathodic protection system components</b> are determined according to environmental regulations, facility requirements and considering impact removal will have on facility
C-21.01.09P	remove existing and dispose of or recycle <b>cathodic protection systems components</b>	<b>cathodic protection system components</b> are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-21.01.10P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**cathodic protection system components** include: AC supply, transformers, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling, jumpers

### Knowledge

	Learning Outcomes	Learning Objectives
C-21.01.01L	demonstrate knowledge of cathodic protection systems and <b>cathodic protection system components</b> , their characteristics, applications and operation	identify terminology associated with cathodic protection systems
		identify types of cathodic protection systems, and describe their characteristics, applications and operation
		identify <b>cathodic protection system components</b> , and describe their characteristics, applications and operation
		interpret information pertaining to cathodic protection systems found on drawings and specifications
		interpret codes and regulations pertaining to cathodic protection systems
C-21.01.02L	demonstrate knowledge of procedures to install, connect, and test cathodic protection systems and <b>cathodic protection system components</b>	identify tools and equipment used to install, connect, and test cathodic protection systems and <b>cathodic protection system components</b> , and describe their applications and procedures for use

describe procedures to install and connect cathodic protection systems and ***cathodic protection system components***

describe procedures to test cathodic protection systems and ***cathodic protection system components***

## Range of Variables

***cathodic protection system components*** include: AC supply, transformers, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling, jumpers

## C-21.02 Maintains cathodic protection systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
C-21.02.01P	select tools and equipment	tools and equipment are selected according to task
C-21.02.02P	verify operation of equipment	equipment operation is verified according to manufacturers' specifications and AHJ requirements by using <b><i>field assessments</i></b> and <b><i>diagnostic and test equipment</i></b>
C-21.02.03P	determine source of malfunction	source of malfunction is determined according to <b><i>field assessments</i></b> and <b><i>diagnostic and test equipment</i></b> results
C-21.02.04P	identify, remove and dispose of or recycle defective <b><i>cathodic protection system components</i></b>	defective <b><i>cathodic protection system components</i></b> are identified, and removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-21.02.05P	repair malfunctioning <b><i>cathodic protection system components</i></b>	repaired <b><i>cathodic protection system components</i></b> are operational
C-21.02.06P	select replacement <b><i>cathodic protection system components</i></b>	OEM or equivalent replacement <b><i>cathodic protection system components</i></b> are selected
C-21.02.07P	install bypass jumpers during repair	bypass jumpers are installed to maintain continuity of protection during repair
C-21.02.08P	install replacement <b><i>cathodic protection system components</i></b>	OEM or equivalent replacement <b><i>cathodic protection system components</i></b> are installed according to manufacturers' specifications and AHJ requirements

C-21.02.09P	conduct tests of <b><i>cathodic protection system components</i></b>	<b><i>cathodic protection system components</i></b> are tested after repair and as required by maintenance schedule, connected and function according to manufacturers' specifications, and facility, AHJ, CSA and CEC requirements, and system operation verified
C-21.02.10P	document test results in maintenance document	operational problems and test results are identified in maintenance schedule data

## Range of Variables

***field assessments*** include: sensory inspections, technical inspections

***diagnostic and test equipment*** includes: multimeter, DC ammeter

***cathodic protection system components*** include: AC supply, transformers, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling, jumpers

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
C-21.02.01L	demonstrate knowledge of <b><i>cathodic protection systems components</i></b> , their characteristics, applications and operation	identify terminology associated with <b><i>cathodic protection systems components</i></b>
		identify types of <b><i>cathodic protection systems components</i></b> , and describe their characteristics, applications and operation
C-21.02.02L	demonstrate knowledge of procedures to maintain <b><i>cathodic protection systems components</i></b>	identify tools and equipment used to maintain <b><i>cathodic protection systems components</i></b> , and describe their applications and procedures for use
		describe procedures to maintain <b><i>cathodic protection systems components</i></b>

## Range of Variables

***cathodic protection system components*** include: AC supply, transformers, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling, jumpers

# Major Work Activity D

## Installs and maintains rotating and other fixed equipment and control systems

### Task D-22 Installs and maintains motor starters and control devices

#### Task Descriptor

All electrical motors need a method to be started, stopped, protected and controlled. These controls can be as simple as a single switch, or as complex as a starter assembly. Industrial electricians install and maintain these starters and controls in the motor circuits. Mechanical starters are being phased out and replaced with solid state starters. This supports energy efficiency and reduces noise pollution.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing motor starters, control devices and their components.

For the purpose of this standard “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

#### D-22.01 Installs motor starters

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

Performance Criteria		Evidence of Attainment
D-22.01.01P	determine type of <b>motor starter</b> for specific application	<b>motor starter</b> is selected and sized according to specific application, drawings, specifications, motor <b>manufacturers’ nameplate data</b> , standards and codes
D-22.01.02P	select tools and equipment	tools and equipment are selected according to task
D-22.01.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-22.01.04P	remove existing <b>motor starter</b> when upgrading	motor starter is removed with minimal impact to surrounding equipment and interruptions to operation

D-22.01.05P	position, mount and assemble <b>starter assembly</b>	<b>starter assembly</b> is placed, mounted and assembled in locations according to electrical drawings, and job and facility requirements
D-22.01.06P	terminate cables	cables are terminated according to manufacturers' specifications and CEC requirements
D-22.01.07P	terminate conductors	conductors are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-22.01.08P	install <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are sized and installed to manufacturers' specifications and CEC requirements
D-22.01.09P	set overloads	overloads are sized for application and adjusted to provide motor running protection according to manufacturers' specifications and CEC requirements
D-22.01.10P	interconnect starter with <b>motor control devices</b> and <b>indicators</b>	interconnections are completed and equipment functions as intended
D-22.01.11P	verify function of <b>motor starter</b>	<b>motor starter</b> is functioning according to <b>application requirements</b>
D-22.01.12P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**motor starters** include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

**manufacturers' nameplate data** includes: size of motor (horsepower), full load current (FLC), service factor, voltage (AC/DC, number of phases), duty, starter size (NEMA, IEC), insulation classification, multi-voltage, speed

**starter assembly** includes: fittings, enclosures, raceways, control transformers, overcurrent protection, overload protection, terminations

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

**overcurrent protection devices** include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected combination motor controllers

**indicators** include: indicating lights, audible devices

**application requirements** include: direction of rotation, RPM, acceleration/deceleration, current draw



## Knowledge

	Learning Outcomes	Learning Objectives
D-22.01.01L	demonstrate knowledge of <b>motor starters</b> , their components, accessories, characteristics, applications, and operation	interpret information pertaining to <b>motor starters</b> found on motor nameplate, drawings and specifications
		identify <b>motor starters</b> and their components and accessories, and describe their characteristics, applications, and operation
		interpret codes and regulations pertaining to <b>motor starters</b>
		identify enclosures and wiring methods based on application
D-22.01.02L	demonstrate knowledge of procedures to install and connect <b>motor starters</b> , their components and accessories	identify tools and equipment used to install and connect <b>motor starters</b> , their components and accessories, and describe their applications and procedures for use
		describe procedures to install <b>motor starters</b> , their components and accessories
		describe procedures to connect <b>motor starters</b> , their components and accessories

### Range of Variables

**motor starters** include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

## D-22.02 Maintains motor starters

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
D-22.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-22.02.02P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results

D-22.02.03P	select tools and equipment	tools and equipment are selected according to task
D-22.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-22.02.05P	repair malfunctioning components	repaired components are operational
D-22.02.06P	select replacement components	OEM or equivalent replacement components are selected
D-22.02.07P	replace defective or damaged components	defective or damaged components are replaced with minimal disruptions and interruptions
D-22.02.08P	clean, lubricate and <b>adjust</b> components	motor starter components are cleaned, lubricated, and <b>adjusted</b> after repair and according to maintenance schedule to restore to OEM <b>component conditions</b>
D-22.02.09P	conduct tests of motor starters after repair	starter assembly is tested after repair and according to maintenance schedule, and is connected and functions according to manufacturers' specifications and facility requirements
D-22.02.10P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-22.02.11P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and comparison with specifications
D-22.02.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-22.02.13P	update documentation	images and drawings reflect operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters

**adjustment procedures** include: inspecting terminations, overload settings, timing settings

**component conditions** include: contact pressure, carbon build-up, pitting on contacts, dirt and moisture

## Knowledge

	Learning Outcomes	Learning Objectives
D-22.02.01L	demonstrate knowledge of <b>motor starters</b> , their components, accessories, characteristics, applications and operation	interpret information pertaining to <b>motor starters</b> found on drawings and specifications  identify <b>motor starters</b> and their components and accessories, and describe their characteristics, applications, and operation
D-22.02.02L	demonstrate knowledge of procedures to maintain <b>motor starters</b>	interpret codes and regulations pertaining to <b>motor starters</b>  identify tools and equipment used to maintain <b>motor starters</b> , and describe their applications and procedures for use  describe procedures to maintain <b>motor starters</b> , their components and accessories

### Range of Variables

**motor starters** include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

### D-22.03 Installs motor control devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
D-22.03.01P	select tools and equipment	tools and equipment are selected according to task
D-22.03.02P	determine type of <b>motor control device</b> and <b>function</b>	<b>motor control device</b> is selected according to application
D-22.03.03P	determine <b>motor control circuit</b> and <b>circuit functional features</b>	<b>motor control circuit</b> types are selected according to application and CEC requirements
D-22.03.04P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-22.03.05P	remove existing <b>motor control device</b> when replacing	<b>motor control device</b> is removed with minimal impact to surrounding equipment and interruptions to operation

D-22.03.06P	position, mount and assemble <b>motor control device</b>	<b>motor control device</b> is placed, mounted and assembled in locations according to electrical drawings, and job and facility requirements
D-22.03.07P	terminate cables	cables are terminated according to CEC requirements
D-22.03.08P	terminate conductors	conductors are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-22.03.09P	set up and adjust <b>motor control devices</b>	<b>motor control devices</b> operate according to application
D-22.03.10P	interconnect <b>motor control devices</b> with <b>indicators</b>	<b>motor control devices</b> are interconnected to <b>indicators</b> , and equipment functions as intended
D-22.03.11P	interconnect <b>motor control devices</b> with overload protection	<b>motor control devices</b> are interconnected to overload protection, interconnections are completed and equipment functions as intended
D-22.03.12P	conduct tests of <b>motor control devices</b>	<b>motor control devices</b> are connected and function according to manufacturers' specifications and facility requirements, and results documented

## Range of Variables

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

**functions** include: starting and stopping, speed control, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, time function

**motor control circuits** include: low-voltage release (two-wire control), low-voltage protection (three-wire control)

**circuit functional features** include: starting and stopping, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, timer function

**indicators** include: indicating lights, audible devices

## Knowledge

	Learning Outcomes	Learning Objectives
D-22.03.01L	demonstrate knowledge of <b>motor control devices</b> , and their characteristics, applications and operation	interpret information pertaining to <b>motor control devices</b> found on drawings and specifications  identify <b>motor control devices</b> , and describe their characteristics, applications and operation  interpret codes and regulations pertaining to <b>motor control devices</b>
D-22.03.02L	demonstrate knowledge of <b>motor control circuits</b> , their characteristics and applications	interpret codes and regulations pertaining to <b>motor control circuits</b>

		identify <b>circuit types</b> , and describe their characteristics and applications
		describe <b>circuit functional features</b> of common hard wired or networked motor control circuits
		identify procedures to determine number of conductors required between controls and controller locations
		identify <b>protection devices for motor control circuits</b> , and describe their characteristics and applications
D-22.03.03L	demonstrate knowledge of procedures to install <b>motor control devices</b>	identify tools and equipment used to install <b>motor control devices</b> , and describe their applications and procedures for use
		describe procedures to install <b>motor control devices</b>

## Range of Variables

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

**motor control circuits** include: low-voltage release (two-wire control), low-voltage protection (three-wire control)

**circuit functional features** include: starting and stopping, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, timer function

**protection devices for control circuits** include: overcurrent devices

## D-22.04 Maintains motor control devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-22.04.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-22.04.02P	select tools and equipment	tools and equipment are selected according to task
D-22.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-22.04.04P	identify and remove defective <b>motor control devices</b> and their components	defective <b>motor control devices</b> and their components are removed without damage to system or other components

D-22.04.05P	clean, lubricate and <b>adjust motor control devices</b> and their components	<b>motor control devices</b> and their components are cleaned, lubricated, and <b>adjusted</b> to restore to OEM <b>conditions</b>
D-22.04.06P	select replacement <b>motor control devices</b> and their components	OEM or replacement <b>motor control devices</b> and their components are selected
D-22.04.07P	install replacement <b>motor control devices</b> and their components	OEM or equivalent replacement <b>motor control devices</b> and their components are installed with minimal disruptions and interruptions
D-22.04.08P	conduct tests of <b>motor control devices</b> and their components	<b>motor control devices</b> and their components are tested after repair and according to maintenance schedule, connected and function according to manufacturers' specifications and facility requirements
D-22.04.09P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-22.04.10P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and comparison with specifications
D-22.04.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-22.04.12P	update documentation	documentation reflects operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

**field assessments** include: sensory inspections, technical inspections (inspecting terminations)

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters

**adjustments** include: calibration (level, position, temperature, timing) of components, securing mounting, positioning

**conditions** include: carbon or dust build-up, pitting on contacts, worn or dirty contacts

## Knowledge

Learning Outcomes	Learning Objectives	
D-22.04.01L	demonstrate knowledge of <b>motor control devices</b> , their components, characteristics, applications and operation	interpret information pertaining to <b>motor control devices</b> found on drawings and specifications
		identify <b>motor control devices</b> and their components, and describe their characteristics, applications, and operation
		interpret codes and regulations pertaining to <b>motor control devices</b>
D-22.04.02L	demonstrate knowledge of procedures to maintain <b>motor control devices</b> and their components	identify tools and equipment used to maintain <b>motor control devices</b> and their components, and describe their applications and procedures for use
		describe procedures to maintain <b>motor control devices</b> and their components

### Range of Variables

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

## Task D-23 Installs and maintains drives

### Task Descriptor

Electrical motors can be controlled by both AC and DC drives to achieve precision operation (e.g. speed, positioning) of the motors depending on the application. Industrial electricians install and maintain these drives in the motor circuits. They also perform maintenance to ensure motor drives and their controls are in good operating condition. For new installations, DC drives are becoming less common as a result of maintenance issues. AC can be rectified easily at a lower cost with less maintenance requirements.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

Both installation and maintenance include programming and tuning.

### D-23.01 Installs AC drives

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
D-23.01.01P	determine type, size and function of AC drive	AC drive is determined according to application and <b>motor nameplate data</b>
D-23.01.02P	select tools and equipment	tools and equipment are selected according to task
D-23.01.03P	calculate conductor and reactor requirements	conductor and reactor type and size are calculated according to application, taking into account <b>conditions</b> and CEC requirements
D-23.01.04P	remove existing AC drives when replacing	AC drive is removed with minimal impact to surrounding equipment and interruption to operation
D-23.01.05P	position, mount and assemble AC drives	AC drive is positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements
D-23.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-23.01.07P	install <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are installed and sized according to manufacturers' specifications and CEC requirements



D-23.01.08P	program AC drives	AC drives programming meet functionality and equipment parameters
D-23.01.09P	interconnect AC drives to <b>motor control devices</b>	AC drives are interconnected to <b>motor control devices</b> , required cables, raceways and conductors, and equipment functions as intended
D-23.01.10P	conduct tests of AC drive	AC drive is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-23.01.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.01.12P	update documentation	documentation reflects operational changes, maintenance history and parameters

## Range of Variables

**motor nameplate data** includes: size of motor (horsepower), FLC, inverter duty rated, voltage, frequency, speed/rpm

**conditions** that affect conductor requirements include: shielding requirements, length of cable, type of VFD rated cable, reactor use, equipment bonding

**overcurrent protection devices** include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected motor controllers

**motor control devices** include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

## Knowledge

	Learning Outcomes	Learning Objectives
D-23.01.01L	demonstrate knowledge of AC drives and <b>AC drive components</b> , their accessories, characteristics, applications and operation	identify types of AC drives, and describe their characteristics, applications and operation
		identify <b>AC drive components</b> and accessories, and describe their characteristics, applications and operation
		interpret information pertaining to AC drives found on drawings and specifications
		interpret codes and regulations pertaining to AC drives
		explain operating principles of AC drives and their impact on motor performance
		identify considerations and requirements for selecting AC drives and <b>AC drive components</b>

D-23.01.02L	demonstrate knowledge of procedures to install and connect AC drives and <b>AC drive components</b>	identify tools and equipment used to install and connect AC drives and <b>AC drive components</b> , and describe their applications and procedures for use
		describe procedures to install AC drives and <b>AC drive components</b>
		describe procedures to program AC drives and <b>AC drive components</b>

## Range of Variables

**AC drive components** include: rectifiers, electro-magnetic compatibility (EMC) filters, DC circuits, inverters, reactors, field components (encoders, tachometers), shielded cables

## D-23.02 Maintains AC drives

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
D-23.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-23.02.02P	select tools and equipment	tools and equipment are selected according to task
D-23.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-23.02.04P	identify and remove defective <b>AC drive components</b>	defective <b>AC drive components</b> are removed with minimal impact to surrounding equipment and interruption to operation
D-23.02.05P	select replacement <b>AC drive components</b>	OEM or equivalent replacement <b>AC drive components</b> are selected
D-23.02.06P	install replacement <b>AC drive components</b>	OEM or equivalent replacement <b>AC drive components</b> are installed with minimal disruptions and interruptions
D-23.02.07P	repair malfunctioning <b>AC drive components</b>	repaired <b>AC drive components</b> are operational
D-23.02.08P	<b>adjust programming</b>	programming is adjusted according to type of repair and changes to operating conditions

D-23.02.09P	conduct tests of AC drives	AC drive assembly is tested after repair and according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements
D-23.02.10P	<b>clean and adjust</b> components	<b>AC drive components</b> are <b>cleaned and adjusted</b> to restore to optimal conditions
D-23.02.11P	compare and analyze <b>drive parameters</b>	maintenance is performed according to analysis of <b>drive parameters</b>
D-23.02.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.02.13P	update documentation	documentation reflects operational changes, maintenance history and parameters

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, oscilloscopes

**cleaning and adjustment** includes: inspecting terminations, cleaning filters and cooling fans, checking door seals

**AC drive components** include: rectifiers, EMC filters, inverters, reactors, field components (encoders, tachometers)

**drive parameters** include: overload, acceleration/deceleration rate, torque, frequency, braking

**adjust programming** includes: using existing program, network

## Knowledge

	Learning Outcomes	Learning Objectives
D-23.02.01L	demonstrate knowledge of AC drives and <b>AC drive components</b> , their characteristics, applications and operation	identify types of AC drives, and describe their characteristics, applications and operation
		identify <b>AC drive components</b> and describe their characteristics, applications and operation
		interpret information pertaining to AC drives found on drawings and specifications
		interpret codes and regulations pertaining to AC drives

		explain operating principles of AC drives and their impact on motor performance
D-23.02.02L	demonstrate knowledge of procedures to maintain AC drives and <b>AC drive components</b>	identify tools and equipment used to maintain AC drives and <b>AC drive components</b> , and describe their applications and procedures for use
		describe procedures to maintain AC drives and <b>AC drive components</b>

## Range of Variables

**AC drive components** include: rectifiers, EMC filters, inverters, reactors, field components (encoders, tachometers)

### D-23.03 Installs DC drives

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-23.03.01P	determine type, size and function of DC drive for specific application	DC drive is selected and sized according to application and <b>motor nameplate data</b>
D-23.03.02P	select tools and equipment	tools and equipment are selected according to task
D-23.03.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-23.03.04P	remove existing DC drives when replacing	existing DC drive is removed with minimal impact to surrounding equipment and interruption to operation
D-23.03.05P	position, mount and assemble DC drives	DC drive is positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements
D-23.03.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturer's specifications, and AHJ, CSA and CEC requirements
D-23.03.07P	install <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are installed and sized according to manufacturers' specifications and CEC requirements
D-23.03.08P	program DC drives	programming of DC drives meets functionality and established parameters

D-23.03.09P	interconnect DC drives to <b>motor control devices</b>	DC drives are interconnected to <b>motor control devices</b> with required cables, raceways and conductors, and equipment functions as intended
D-23.03.10P	conduct tests of DC drive	DC drive is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-23.03.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.03.12P	update documentation	documentation reflects operational changes and maintenance history

## Range of Variables

**motor nameplate data** includes: size of motor (horsepower), FLC, voltage, speed/rpm

**overcurrent protection devices** include: fuses, inverse time circuit breakers, instantaneous trip circuit breakers, self-protected motor controllers

**motor control devices** include: start/stop stations, emergency stop stations, speed control, sensing devices, encoders, tachometers, limit switches

Knowledge		
	Learning Outcomes	Learning Objectives
D-23.03.01L	demonstrate knowledge of DC drives and <b>DC drive components</b> , their characteristics, applications and operation	identify types of DC drives, and describe their characteristics, applications and operation
		identify <b>DC drive components</b> , and describe their characteristics, applications and operation
		interpret information pertaining to DC drives found on drawings and specifications
		interpret codes and regulations pertaining to DC drives
		explain operating principles of DC drives and their impact on motor performance
		identify considerations and requirements for selecting DC drives and <b>DC drive components</b>
		D-23.03.02L
		describe procedures to install DC drives and <b>DC drive components</b>

describe procedures to connect DC drives and **DC drive components**

describe procedures to program DC drives and **DC drive components**

## Range of Variables

**DC drive components** include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, and field components (encoders and tachometers)

### D-23.04 Maintains DC drives

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-23.04.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-23.04.02P	select tools and equipment	tools and equipment are selected according to task
D-23.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-23.04.04P	identify and remove defective components	defective components are removed with minimal impact to surrounding equipment and interruption to operation
D-23.04.05P	select replacement components	OEM or equivalent replacement components are selected
D-23.04.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions
D-23.04.07P	repair malfunctioning components	repaired components are repaired and tested to ensure they are operational
D-23.04.08P	conduct tests of DC drives	DC drive assembly is tested after repair and according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements
D-23.04.09P	<b>clean and adjust</b> components	DC drive components are <b>cleaned and adjusted</b> to restore to optimal conditions

D-23.04.10P	compare and analyze <b>drive parameters</b>	maintenance is performed according to comparison and analysis of <b>drive parameters</b>
D-23.04.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.04.12P	update documentation	documentation reflects operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, oscilloscopes

**cleaning and adjustment** includes: inspecting terminations, cleaning filters and cooling fans

**drive parameters** include: feedback, acceleration/deceleration rate, torque, braking, max speed/base speed, maximum/minimum field current

## Knowledge

	Learning Outcomes	Learning Objectives
D-23.04.01L	demonstrate knowledge of DC drives and <b>DC drive components</b> , their characteristics, applications and operation	identify types of DC drives, and describe their characteristics, applications and operation
		identify <b>DC drive components</b> , and describe their characteristics, applications and operation
		interpret information pertaining to DC drives found on drawings and specifications
		interpret codes and regulations pertaining to DC drives
		explain operating principles of DC drives and their impact on motor performance
D-23.04.02L	demonstrate knowledge of procedures to maintain DC drives and <b>DC drive components</b>	identify tools and equipment used to maintain DC drives and <b>DC drive components</b> , and describe their applications and procedures for use
		describe procedures to maintain DC drives and <b>DC drive components</b>

## Range of Variables

**DC drive components** include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, and field components (encoders and tachometers)

## Task D-24 Installs and maintains other fixed equipment and associated controls

### Task Descriptor

Other fixed equipment includes welding equipment, electro-magnets, electrostatic precipitators and other non-rotating devices and their associated controls not included elsewhere in this standard. Industrial electricians must install and maintain this equipment.

For the purpose of this standard, “other fixed equipment” also includes welders, conveyers, x-ray equipment and other industrial equipment where the equipment at hand can be hardwired or plugged-in.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### D-24.01 Installs other fixed equipment and associated controls

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-24.01.01P	determine type of <b>other fixed equipment</b> and controls required	<b>other fixed equipment</b> and controls are determined according to manufacturers' specifications, and facility and CEC requirements
D-24.01.02P	select tools and equipment	tools and equipment are selected according to task
D-24.01.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-24.01.04P	install <b>overcurrent protection devices</b>	<b>overcurrent protection devices</b> are installed and sized to manufacturers' specifications and CEC requirements
D-24.01.05P	remove existing <b>other fixed equipment</b> and controls when replacing	existing <b>other fixed equipment</b> and controls are removed with minimal impact to surrounding equipment and interruption to operation



D-24.01.06P	position, mount and assemble <b>other fixed equipment</b> and controls	<b>other fixed equipment</b> and controls are positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements
D-24.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-24.01.08P	conduct tests of <b>other fixed equipment</b> and controls	<b>other fixed equipment</b> and controls are tested after installation, connected and function according to manufacturers' specifications and facility requirements, and results documented
D-24.01.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-24.01.10P	update documentation	documentation reflects changes and maintenance history

## Range of Variables

**other fixed equipment** includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

**overcurrent protection devices** include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected motor controllers

## Knowledge

	Learning Outcomes	Learning Objectives
D-24.01.01L	demonstrate knowledge of <b>other fixed equipment</b> and controls, their characteristics, applications and operation	identify types of <b>other fixed equipment</b> and controls, and describe their characteristics, applications and operation
		identify other fixed equipment components, and describe their characteristics and applications
		interpret codes and regulations for overcurrent protection, conductor sizing and disconnect locations
		interpret information found on drawings and specifications
		explain operating principles of <b>other fixed equipment</b> and controls
		interpret information contained on other fixed equipment nameplates
		identify considerations and requirements for selecting <b>other fixed equipment</b> and controls, and their components

D-24.01.02L	demonstrate knowledge of procedures to install and connect <b>other fixed equipment</b> and controls	identify tools and equipment used to install and connect <b>other fixed equipment</b> and controls, and describe their applications and procedures for use
		describe procedures to install <b>other fixed equipment</b> and controls
		describe procedures to connect <b>other fixed equipment</b> and controls

## Range of Variables

**other fixed equipment** includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

## D-24.02 Maintains other fixed equipment and associated controls

<b>NL</b>	<b>NS</b>	<b>PE</b>	<b>NB</b>	<b>QC</b>	<b>ON</b>	<b>MB</b>	<b>SK</b>	<b>AB</b>	<b>BC</b>	<b>NT</b>	<b>YT</b>	<b>NU</b>
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-24.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-24.02.02P	select tools and equipment	tools and equipment are selected according to task
D-24.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-24.02.04P	identify and remove defective <b>components</b>	defective <b>components</b> are removed without damage to system or other <b>components</b>
D-24.02.05P	select replacement <b>components</b>	OEM or equivalent replacement <b>components</b> are selected
D-24.02.06P	install replacement <b>components</b>	OEM or equivalent replacement <b>components</b> are installed with minimal disruptions and interruptions
D-24.02.07P	conduct <b>tests</b> of <b>other fixed equipment</b> and controls	<b>other fixed equipment</b> and controls are <b>tested</b> after repair or according to maintenance schedule, and assembly is connected and functions according to specifications
D-24.02.08P	clean and adjust <b>components</b>	<b>components</b> are cleaned and adjusted to restore to optimal conditions

D-24.02.09P	compare and analyze maintenance <b>test</b> results	maintenance is performed when required according to analysis of <b>test</b> results and comparison with specifications
D-24.02.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-24.02.11P	update documentation	documentation reflects changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers

**components** include: overcurrent protection, conductors, disconnects, cord sets

**other fixed equipment** includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

**tests** include: insulation, current, baseline

## Knowledge

	Learning Outcomes	Learning Objectives
D-24.02.01L	demonstrate knowledge of <b>other fixed equipment</b> and controls, their components, characteristics, applications and operation	identify types of <b>other fixed equipment</b> and controls, and describe their characteristics, applications and operation
		identify other fixed equipment components, and describe their characteristics and applications
		interpret codes and regulations
		interpret information found on drawings and specifications
D-24.02.02L	demonstrate knowledge of procedures to maintain <b>other fixed equipment</b> and controls, and their components	explain industrial and operating principles of <b>other fixed equipment</b> and controls
		identify tools and equipment used to maintain <b>other fixed equipment</b> and controls, and describe their applications and procedures for use
		describe procedures to maintain <b>other fixed equipment</b> and controls, and their components

## Range of Variables

**other fixed equipment** includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

## Task D-25 Installs and maintains motors

### Task Descriptor

Motors are used to convert electrical energy to rotational kinetic (mechanical) energy. Industrial electricians install and maintain single-phase, three-phase and DC motors.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### D-25.01 Installs single-phase motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-25.01.01P	determine type of <b>single-phase motor</b> required	type of <b>single-phase motor</b> is selected according to <b>operating considerations</b>
D-25.01.02P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-25.01.03P	select tools and equipment	tools and equipment are selected according to task
D-25.01.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <b>motor nameplate data</b> and CEC requirements
D-25.01.05P	position, mount and assemble <b>single-phase motor</b>	<b>single-phase motor</b> is positioned, mounted and assembled according to application
D-25.01.06P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.01.07P	connect motor leads	motor leads are connected according to application, supply voltage and rotation

D-25.01.08P	conduct <b>tests</b> of <b>single-phase motor</b>	<b>single-phase motor</b> is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-25.01.09P	remove existing <b>single-phase motor</b> when replacing	existing <b>single-phase motor</b> is removed with minimal impact to environment
D-25.01.10P	update documentation	documentation reflects operational changes and maintenance history

## Range of Variables

**single-phase motors** include: universal, shaded pole, resistance-start-induction-run (split phase), capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

**operating considerations** include: torque requirement, voltage availability, motor function, rotation, location

**motor nameplate data** includes: size of motor (horsepower), FLC, service factor, voltage, duty, speed/rpm, frequency, insulation class, ambient temperature, enclosure type

**tests** include: vibration, insulation, current, rotation, baseline motor diagnostic test

Knowledge		
	Learning Outcomes	Learning Objectives
D-25.01.01L	demonstrate knowledge of <b>single-phase motors</b> and <b>single-phase motor components</b> , their characteristics, applications and operation	identify types of <b>single-phase motors</b> , and describe their characteristics, applications and operation
		identify terminology pertaining to <b>single-phase motors</b>
		identify <b>single-phase motor components</b> , and describe their characteristics and applications
		interpret codes and regulations pertaining to <b>single-phase motors</b>
		interpret information on drawings and specifications
		explain operating principles of <b>single-phase motors</b>
		interpret information contained on single-phase motor nameplates
		identify <b>operating considerations</b> and requirements for selecting <b>single-phase motors</b> and <b>single-phase motor components</b>
D-25.01.02L	demonstrate knowledge of procedures to install and connect <b>single-phase motors</b> and <b>single-phase motor components</b>	identify tools and equipment used to install and connect <b>single-phase motors</b> and <b>single-phase motor components</b> , and describe their applications and procedures for use

describe procedures to install **single-phase motors** and **single-phase motor components**

describe procedures to connect **single-phase motors** and **single-phase motor components**

## Range of Variables

**single-phase motors** include: universal, shaded pole, resistance-start-induction-run, capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

**single-phase motor components** include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

**operating considerations** include: torque requirement, voltage availability, motor function, rotation, location

## D-25.02 Maintains single-phase motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-25.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-25.02.02P	select tools and equipment	tools and equipment are selected according to task
D-25.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-25.02.04P	identify and remove defective <b>single-phase motor components</b>	defective <b>single-phase motor components</b> are removed without damage to system or other components
D-25.02.05P	select replacement <b>single-phase motor components</b>	OEM or equivalent replacement <b>single-phase motor components</b> are selected
D-25.02.06P	install replacement <b>single-phase motor components</b>	OEM or equivalent replacement <b>single-phase motor components</b> are installed with minimal disruptions and interruptions
D-25.02.07P	conduct <b>tests</b> of single-phase motors	single-phase motor assembly is tested after repair and according to maintenance schedule, connected and functions according to specifications
D-25.02.08P	<b>clean, lubricate and adjust single-phase motor components</b>	<b>single-phase motor components</b> are <b>cleaned, lubricated, and adjusted</b> to restore to optimal conditions

D-25.02.09P	document <b>test</b> results in maintenance schedule	operational problems and <b>test</b> results are documented in maintenance schedule data with detailed notations
D-25.02.10P	compare and analyze maintenance <b>test</b> results	maintenance is performed according to analysis of <b>test</b> results and comparison with specifications
D-25.02.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.02.12P	update documentation	documentation reflects operational changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers, vibration analyzer

**single-phase motor components** include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

**clean, lubricate and adjust** includes: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches

**tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

## Knowledge

	Learning Outcomes	Learning Objectives
D-25.02.01L	demonstrate knowledge of <b>single-phase motors</b> and <b>single-phase motor components</b> , their characteristics, applications and operation	identify types of <b>single-phase motors</b> and describe their characteristics, applications and operation
		identify terminology pertaining to <b>single-phase motors</b>
		identify <b>single-phase motor components</b> , and describe their applications
		interpret codes and regulations pertaining to <b>single-phase motors</b>
		interpret information found on drawings and specifications
		explain industrial and operating principles of <b>single-phase motors</b>
		interpret information contained on single-phase motor nameplates

D-25.02.02L	demonstrate knowledge of procedures to maintain <b>single-phase motors</b> and <b>single-phase motor components</b>	identify tools and equipment used to maintain <b>single-phase motors</b> and <b>single-phase motor components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>single-phase motors</b> and <b>single-phase motor components</b>

## Range of Variables

**single-phase motors** include: universal, shaded pole, resistance-start-induction-run, capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

**single-phase motor components** include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

## D-25.03 Installs three-phase motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-25.03.01P	determine type of <b>three-phase motor</b> required	type of <b>three-phase motor</b> is selected according to <b>operating considerations</b>
D-25.03.02P	select tools and equipment	tools and equipment are selected according to task
D-25.03.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-25.03.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <b>motor nameplate data</b> and CEC requirements
D-25.03.05P	position and mount <b>three-phase motor</b>	<b>three-phase motor</b> is placed, mounted and assembled according to application
D-25.03.06P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.03.07P	connect motor leads	motor leads are connected according to application, supply voltage and rotation
D-25.03.08P	conduct <b>tests</b> of <b>three-phase motor</b>	<b>three-phase motor</b> is <b>tested</b> after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented



D-25.03.09P	remove existing <b>three-phase motor</b> when replacing	existing <b>three-phase motor</b> is removed with minimal impact to environment
D-25.03.10P	update documentation	documentation reflects changes and maintenance history

## Range of Variables

**three-phase motors** include: squirrel cage induction, synchronous, wound rotor induction

**operating considerations** include: supply voltage, motor function, rotation, location

**motor nameplate data** includes: size of motor (horsepower), FLC, service factor, voltage, speed/rpm, frequency, insulation class, ambient temperature, enclosure type, duty cycle

**tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

Knowledge		
	Learning Outcomes	Learning Objectives
D-25.03.01L	demonstrate knowledge of <b>three-phase motors</b> , their components, characteristics, applications and operation	identify types of <b>three-phase motors</b> , and describe their characteristics, applications and operation identify terminology pertaining to <b>three-phase motors</b> identify three-phase motor components, and describe their characteristics and applications interpret codes and regulations pertaining to <b>three-phase motors</b> interpret information found on drawings and specifications explain operating principles of <b>three-phase motors</b> interpret information contained on three-phase motor nameplates identify considerations and requirements for selecting <b>three-phase motors</b> and their components
D-25.03.02L	demonstrate knowledge of procedures to install and connect <b>three-phase motors</b> and their components	identify tools and equipment used to install and connect <b>three-phase motors</b> and their components, and describe their applications and procedures for use describe procedures to install <b>three-phase motors</b> and their components describe procedures to connect <b>three-phase motors</b> and their components

## Range of Variables

**three-phase motors** include: squirrel cage induction, synchronous, wound rotor induction

## D-25.04 Maintains three-phase motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-25.04.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-25.04.02P	select tools and equipment	tools and equipment are selected according to task
D-25.04.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-25.04.04P	identify and remove defective <b>three-phase motor components</b>	defective <b>three-phase motor components</b> are removed without damage to system or other components
D-25.04.05P	select replacement <b>three-phase motor components</b>	OEM or equivalent replacement <b>three-phase motor components</b> are selected
D-25.04.06P	install replacement <b>three-phase motor components</b>	OEM or equivalent replacement <b>three-phase motor components</b> are installed with minimal disruptions and interruptions
D-25.04.07P	conduct <b>tests</b> of <b>three-phase motors</b>	<b>three-phase motor</b> assembly is tested after repair and according to maintenance schedule, connected and functions according to specifications
D-25.04.08P	<b>clean, lubricate and adjust three-phase motor components</b>	<b>three-phase motor components</b> are <b>cleaned, lubricated and adjusted</b> to restore to optimal conditions
D-25.04.09P	document <b>test</b> results in maintenance schedule	operational problems and <b>test</b> results are identified and documented in maintenance schedule data with detailed notations
D-25.04.10P	compare and analyze maintenance <b>test</b> results	maintenance is performed according to according to analysis of <b>test</b> results and comparison with specifications
D-25.04.11P	label conductors and corresponding terminals or leads	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.04.12P	update documentation	documentation reflects changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers

**tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

**clean, lubricate and adjust** includes: cleaning cooling fans, lubricating bearings, cleaning switches, checking slip rings and brushes

**three-phase motors** include: squirrel cage induction, synchronous, wound rotor induction, linear induction

**three-phase motor components** include: frame, rotor, stator, end bells, fans, brushes, bearings, slip rings, lifting eyes

Knowledge		
	Learning Outcomes	Learning Objectives
D-25.04.01L	demonstrate knowledge of <b>three-phase motors</b> and <b>three-phase motor components</b> , their characteristics, applications and operation	identify types of <b>three-phase motors</b> , and describe their characteristics, applications and operation
		identify terminology pertaining to <b>three-phase motors</b>
		identify <b>three-phase motor components</b> , and describe their characteristics and applications
		interpret codes and regulations pertaining to <b>three-phase motors</b>
		interpret information found on drawings and specifications
		explain operating principles of <b>three-phase motors</b>
		interpret information contained on three-phase motor nameplates
D-25.04.02L	demonstrate knowledge of procedures to maintain <b>three-phase motors</b> and <b>three-phase motor components</b>	identify tools and equipment used to maintain <b>three-phase motors</b> and <b>three-phase motor components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>three-phase motors</b> and <b>three-phase motor components</b>

## Range of Variables

**three-phase motors** include: squirrel cage induction, wound rotor induction, synchronous

**three-phase motor components** include: frame, rotor, stator, end bells, fans, brushes, bearings, slip rings, lifting eyes

### D-25.05 Installs DC motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

Performance Criteria		Evidence of Attainment
D-25.05.01P	determine type of <b>DC motor</b> required	<b>DC motor</b> to be installed is determined according to <b>operating conditions</b>
D-25.05.02P	select tools and equipment	tools and equipment are selected according to task
D-25.05.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-25.05.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <b>motor nameplate data</b> and CEC requirements
D-25.05.05P	remove existing <b>DC motors</b> when replacing	existing <b>DC motors</b> are removed with minimal impact to environment
D-25.05.06P	position and mount <b>DC motor</b>	<b>DC motor</b> is positioned and mounted according to application
D-25.05.07P	connect motor leads	motor leads are connected according to application, supply voltage, rotation and configuration
D-25.05.08P	conduct <b>tests</b> of <b>DC motor</b>	<b>DC motor</b> is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-25.05.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.05.10P	update documentation	documentation reflect changes and maintenance history

## Range of Variables

**DC motors** include: self-excited, separately excited, series, shunt, compound, dual field/combination

**operating conditions** include: voltage availability, motor function, rotation, location

**motor nameplate data** includes: base speed/rpm, size of motor (horsepower), FLC, service factor, voltage, insulation class, ambient temperature, enclosure type, duty cycle

**tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

<b>Knowledge</b>		
	<b>Learning Outcomes</b>	<b>Learning Objectives</b>
D-25.05.01L	demonstrate knowledge of <b>DC motors</b> , <b>DC motor components</b> , their characteristics, applications and operation	identify types of <b>DC motors</b> , and describe their characteristics, applications and operation
		identify terminology pertaining to <b>DC motors</b>
		identify <b>DC motor components</b> , and describe their characteristics and applications
		interpret codes and regulations pertaining to <b>DC motors</b>
		interpret information found on drawings and specifications
		explain operating principles of <b>DC motors</b>
		interpret information contained on DC motor nameplates
D-25.05.02L	demonstrate knowledge of procedures to install and connect <b>DC motors</b> and <b>DC motor components</b>	identify tools and equipment used to install and connect <b>DC motors</b> and <b>DC motor components</b> , and describe their applications and procedures for use
		describe procedures to install <b>DC motors</b> , <b>DC motor components</b> , and their controls
		describe procedures to connect <b>DC motors</b> , <b>DC motor components</b> , and their controls

## Range of Variables

**DC motors** include: self-excited, separately excited, series, shunt, compound, dual field/combination

**DC motor components** include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

## D-25.06 Maintains DC motors

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
D-25.06.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
D-25.06.02P	select tools and equipment	tools and equipment are selected according to task
D-25.06.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
D-25.06.04P	identify and remove defective <b>DC motor components</b>	defective <b>DC motor components</b> are removed without damage to system or other components
D-25.06.05P	select replacement <b>DC motor components</b>	OEM or equivalent replacement <b>DC motor components</b> are selected
D-25.06.06P	install replacement <b>DC motor components</b>	OEM or equivalent replacement <b>DC motor components</b> are installed with minimal disruptions and interruptions
D-25.06.07P	conduct <b>tests</b> of <b>DC motors</b>	<b>DC motor</b> assembly is tested after repair or according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements
D-25.06.08P	<b>clean, lubricate and adjust DC motor components</b>	<b>DC motor components</b> are <b>cleaned, lubricated, and adjusted</b> to restore to optimal conditions
D-25.06.09P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-25.06.10P	compare and analyze maintenance <b>test</b> results	maintenance is performed according to analysis of <b>test</b> results and comparison with specifications
D-25.06.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.06.12P	update documentation	documentation reflects changes and maintenance history

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**DC motors** include: self-excited, separately excited, series, shunt, compound, dual field/combination

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers, isolated oscilloscope, DC hi-pot testers, growlers

**tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

**clean, lubricate and adjust** includes: cleaning cooling fans, lubricating bearings and bushings, cleaning switches, cleaning and adjusting brushes, cleaning commutator segments

**DC motor components** include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

Knowledge		
Learning Outcomes	Learning Objectives	
D-25.06.01L	demonstrate knowledge of <b>DC motors</b> and <b>DC motor components</b> , their characteristics, applications and operation	identify types of <b>DC motors</b> , and describe their characteristics, applications and operation
		identify terminology pertaining to <b>DC motors</b>
		identify <b>DC motor components</b> , and describe their characteristics and applications
		interpret codes and regulations pertaining to <b>DC motors</b>
		interpret information found on drawings and specifications
		explain operating principles of <b>DC motors</b>
		interpret information contained on DC motor nameplates
D-25.06.02L	demonstrate knowledge of procedures to maintain <b>DC motors</b> and <b>DC motor components</b>	identify tools and equipment used to maintain <b>DC motors</b> and <b>DC motor components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>DC motors</b> and <b>DC motor components</b>

## Range of Variables

**DC motors** include: self-excited, separately excited, series, shunt, compound, dual field/combination

**DC motor components** include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

# Major Work Activity E

## Installs and maintains signalling and communication systems

### Task E-26 Installs and maintains signalling systems

#### Task Descriptor

Industrial electricians install, upgrade, and maintain signalling systems such as fire alarm systems, and security and surveillance systems which allow for the protection and management of people and property. These types of systems may be low-voltage circuits, extra-low-voltage circuits, and Class 1 or Class 2 circuits.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by adding, removing and replacing components.

For the purpose of this standard, “maintain” includes inspections, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

#### E-26.01 Installs fire alarm systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
E-26.01.01P	determine type of <b>fire alarm system</b> required	type of <b>fire alarm system</b> is determined according to electrical drawings, specifications, <b>codes, standards and regulations</b>
E-26.01.02P	select tools and equipment	tools and equipment are selected according to task
E-26.01.03P	remove and dispose of or recycle existing <b>fire alarm system components</b> when upgrading	<b>fire alarm system components</b> are disposed of or recycled according to codes and waste disposal requirements
E-26.01.04P	determine <b>fire alarm system</b> layout	<b>fire alarm system</b> layout is determined according to walkthrough of building to identify and mark interference locations on drawings according to manufacturers' specifications, <b>codes, standards and regulations</b>



E-26.01.05P	select <b>fire alarm system components</b>	<b>fire alarm system components</b> are selected according to electrical drawings, manufacturers' specifications, <b>codes, standards and regulations</b>
E-26.01.06P	position, mount and assemble <b>fire alarm system components</b>	<b>fire alarm system components</b> are positioned, mounted and assembled in locations according to electrical drawings, <b>codes, standards and regulations</b>
E-26.01.07P	terminate and interconnect <b>fire alarm system components</b> and <b>associated systems</b>	<b>fire alarm system components</b> and <b>associated system</b> devices are terminated and interconnected according to electrical drawings, manufacturers' specifications, job requirements, <b>codes, standards and regulations</b>
E-26.01.08P	test <b>fire alarm system components</b>	<b>fire alarm system components</b> are tested to ensure functionality
E-26.01.09P	test cables	cables are tested for continuity, shorts between conductors, and shorts between conductors and ground
E-26.01.10P	conduct an initial test of <b>fire alarm system</b>	sensory and spot tests and initial <b>fire alarm system</b> tests are performed according to manufacturers' specifications, <b>codes, standards and regulations</b>
E-26.01.11P	participate in start-up, commissioning and verification	start-up, commissioning and verification is conducted on <b>fire alarm system, fire alarm system components</b> and <b>associated systems</b> according to design and manufacturers' specifications, <b>codes, standards and regulations</b>
E-26.01.12P	update <b>documentation</b> for <b>fire alarm systems</b>	<b>documentation</b> is updated according to <b>codes, standards and regulations</b> , and reflects commissioning activities

## Range of Variables

**fire alarm systems** include: addressable (data communication link, Class A [DCLA]- data communication link, Class B [DCLB]- data communication link, Class C [DCLC]) and non-addressable (Class A – Class B) systems (single stage, two stage, single zone, multi-zone)

**fire alarm system components** include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

**associated systems** include: fire suppression systems, emergency power supplies fan shutdown/startup, public address (PA) systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

**codes, standards and regulations** include: CAN/Underwriters Laboratory of Canada (ULC)-S524, CAN/ULC-S536, CAN/ULC-S537, National Building Code (NBC) and local building codes, National Fire Code of Canada (NFC) and local fire codes, CEC, regulations specific to AHJ

**documentation** includes: maintenance logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, fire alarm verification report form

Knowledge		
	Learning Outcomes	Learning Objectives
E-26.01.01L	demonstrate knowledge of <b>fire alarm systems</b> and <b>fire alarm system components</b> , their characteristics, applications and operation	interpret <b>codes, standards and regulations</b> pertaining to <b>fire alarm systems</b>
		interpret information found on drawings and manufacturers' specifications
		identify types of <b>fire alarm systems</b> , and describe their characteristics and applications
		describe types of <b>associated systems</b> that are interconnected with <b>fire alarm systems</b>
		identify <b>fire alarm system components</b> , and describe their characteristics and applications
		identify considerations and requirements for selecting <b>fire alarm systems</b> and <b>fire alarm system components</b>
E-26.01.02L	demonstrate knowledge of procedures to install, upgrade and connect <b>fire alarm systems</b> and <b>fire alarm system components</b> , and their connections to <b>associated/ancillary systems</b>	identify tools and equipment used to install, upgrade and connect <b>fire alarm systems</b> and <b>fire alarm system components</b> , and their connections to <b>associated/ancillary systems</b> , and describe their applications and procedures for use
		describe procedures to install, upgrade and connect <b>fire alarm systems</b> and <b>fire alarm system components</b>

describe procedures to interconnect **associated/ancillary systems** with **fire alarm systems**

describe procedures for testing **fire alarm systems** and **fire alarm system components**

describe procedures for start-up, commissioning and verification of **fire alarm systems**

## Range of Variables

**fire alarm systems** include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems (single stage, two stage, single zone, multi-zone)

**codes, standards and regulations** include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC and local building codes, NFC and local fire codes, CEC, regulations specific to AHJ

**associated/ancillary systems** include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

**fire alarm system components** include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

## E-26.02 Maintains fire alarm systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-26.02.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
E-26.02.02P	select tools and equipment	tools and equipment are selected according to task
E-26.02.03P	identify existing <b>fire alarm system</b> and <b>fire alarm system components</b>	existing <b>fire alarm system</b> and <b>fire alarm system components</b> are identified according to <b>documentation</b>
E-26.02.04P	test <b>fire alarm system</b>	tests are performed according to <b>codes, standards and regulations</b> , manufacturers' specifications and maintenance schedule; sensory inspections and technical inspections are performed using <b>diagnostic and test equipment</b>

E-26.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-26.02.06P	participate in periodic inspections	<b>fire alarm system, fire alarm system components, and associated/ancillary systems</b> function according to manufacturers' specifications and are inspected according to maintenance schedule
E-26.02.07P	select replacement <b>fire alarm system components</b>	OEM or equivalent replacement <b>fire alarm system components</b> are selected according to manufacturers' specifications, facility requirements, <b>codes, standards and regulations</b>
E-26.02.08P	replace <b>fire alarm system components</b>	OEM or equivalent replacement <b>fire alarm system components</b> are tested and verified according to <b>codes, standards and regulations</b>
E-26.02.09P	participate in start-up and verification	start-up and verification is conducted on <b>fire alarm system, fire alarm system components</b> and <b>associated systems</b> according to design and manufacturers' specifications, and <b>codes, standards and regulations</b>
E-26.02.10P	update <b>documentation</b>	<b>documentation</b> is clear, detailed and includes systems and components tested, test results and changes that were completed according to <b>codes, standards and regulations</b>

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**fire alarm systems** include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems (single stage, two stage, single zone, multi-zone)

**fire alarm system components** include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

**diagnostic and test equipment** includes: multimeters, voltage testers, sound pressure level (SPL) meters, heat lamp, smoke canisters

**associated/ancillary systems** include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

**codes, standards and regulations** include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC and local building codes, NFC and local fire codes, CEC, regulations specific to AHJ

**documentation** includes: maintenance logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, manufacturers' certification, equipment log

Knowledge		
	Learning Outcomes	Learning Objectives
E-26.02.01L	demonstrate knowledge of <b>fire alarm systems</b> and <b>fire alarm system components</b> , their characteristics, applications and operation	identify types of <b>fire alarm systems</b> , and describe their characteristics and applications
		interpret information pertaining to <b>fire alarm systems</b> found on drawings and manufacturers' specifications
		interpret <b>codes, standards and regulations</b> pertaining to <b>fire alarm systems</b>
		identify <b>fire alarm system components</b> , and describe their characteristics and applications
		identify considerations and requirements for selecting <b>fire alarm systems</b> and <b>fire alarm system components</b>
		identify and describe types of <b>associated/ancillary systems</b> that interconnect with <b>fire alarm systems</b>
		describe possible effects of <b>fire alarm system</b> maintenance on <b>associated/ancillary systems</b>

E-26.02.02L	demonstrate knowledge of procedures to maintain <b>fire alarm systems</b> and <b>fire alarm system components</b>	identify tools and equipment used to maintain <b>fire alarm systems</b> and <b>fire alarm system components</b> , and describe their applications and procedures for use
		describe procedures to service and maintain <b>fire alarm systems</b> and <b>fire alarm system components</b>
		describe procedures for testing <b>fire alarm systems</b> and <b>fire alarm system components</b>

## Range of Variables

**fire alarm systems** include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems (single stage, two stage, single zone, multi-zone)

**codes, standards and regulations** include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC and local building codes, NFC and local fire codes, CEC, CSA standard M421

**fire alarm system components** include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

**associated/ancillary systems** include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

## E-26.03 Installs security and surveillance systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-26.03.01P	identify type of <b>security and surveillance system</b> required for new installation	type of <b>security and surveillance system</b> is identified according to electrical drawings, specifications and job requirements
E-26.03.02P	select tools and equipment	tools and equipment are selected according to task
E-26.03.03P	remove and dispose of existing <b>security and surveillance system</b> when upgrading	all <b>security and surveillance system components</b> are disposed of according to environmental standards and regulations
E-26.03.04P	determine <b>security and surveillance system</b> layout	<b>security and surveillance system</b> layout is determined according to architectural and facility requirements

E-26.03.05P	select <b>security and surveillance system components</b>	<b>security and surveillance system components</b> are selected according to electrical drawings, specifications, job and facility requirements
E-26.03.06P	position, mount and assemble <b>security and surveillance system components</b>	<b>security and surveillance system components</b> are positioned, mounted and assembled in locations according to electrical drawings, specifications, and job and facility requirements
E-26.03.07P	terminate and interconnect <b>security and surveillance system components</b> and <b>associated systems</b>	<b>security and surveillance system components</b> and <b>associated systems</b> are terminated and interconnected according to electrical drawings, specifications and job requirements
E-26.03.08P	program and configure <b>security and surveillance system</b>	<b>security and surveillance system</b> is programmed and configured according to manufacturers' specifications, and job and facility requirements
E-26.03.09P	test cables	cables are tested for continuity and polarity of voice data and video data wiring ensuring cables have no opens and all <b>security and surveillance system components</b> are bonded to ground according to CEC requirements
E-26.03.10P	conduct initial <b>security and surveillance system</b> tests	sensory and spot tests are performed; and <b>security and surveillance system</b> tests are performed according to electrical drawings and specifications, and AHJ requirements
E-26.03.11P	participate in start-up and commissioning inspections	devices are activated to trigger <b>events</b> , and <b>associated systems'</b> responses according to manufacturers' specifications and facility requirements
E-26.03.12P	update <b>documentation</b> to reflect testing, inspections and maintenance performed	<b>documentation</b> is clear, detailed and includes systems and components tested, test results and changes that were completed

## Range of Variables

**security and surveillance systems** include: perimeter, space, spot

**security and surveillance system components** include: cameras, monitors, digital video recorders (DVR), motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, radio frequency identification (RFID) tags, key pads, power supplies, servers, graphical user interfaces (GUI)

**events** include: system surveillance logs, notifications, alarms

**associated systems** include: central alarm monitoring, automatic doors, local area network (LAN), building automation systems, lighting

**documentation** includes: maintenance logs, as-builts

## Knowledge

Learning Outcomes	Learning Objectives	
E-26.03.01L	demonstrate knowledge of <b>security and surveillance systems</b> and <b>security and surveillance system components</b> , their characteristics, applications and operation	interpret codes and regulations pertaining to <b>security and surveillance systems</b>
		interpret information pertaining to <b>security and surveillance systems</b> found on drawings and specifications
		identify types of <b>security and surveillance systems</b> , and describe their characteristics, applications and operation
		describe types of <b>associated systems</b> that are interconnected with <b>security and surveillance systems</b>
		identify <b>security and surveillance system components</b> , and describe their characteristics and applications
E-26.03.02L	demonstrate knowledge of procedures to install, upgrade and connect <b>security and surveillance systems</b> and <b>security and surveillance system components</b>	identify tools and equipment used to install, upgrade and connect <b>security and surveillance systems</b> and <b>security and surveillance system components</b> , and describe their applications and procedures for use
		describe procedures to install, upgrade and connect <b>security and surveillance systems</b> and <b>security and surveillance system components</b>
		describe procedures for testing <b>security and surveillance systems</b> and <b>security and surveillance system components</b>
		describe procedures for start-up, commissioning and verification of <b>security and surveillance systems</b>

### Range of Variables

**security and surveillance systems** include: perimeter, space, spot

**security and surveillance system components** include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs

**associated systems** include: central alarm monitoring, automatic doors, LAN, building automation systems, lighting



## E-26.04 Maintains security and surveillance systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-26.04.01P	obtain detailed description of malfunction	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
E-26.04.02P	select tools and equipment	tools and equipment are selected according to task
E-26.04.03P	identify existing <b>security and surveillance system</b> and <b>security and surveillance system components</b>	as-built drawings and maintenance log are referenced to identify existing <b>security and surveillance system</b> and a walkthrough is conducted
E-26.04.04P	conduct security and surveillance system tests	security and surveillance system tests are performed according to sensory inspections, and technical inspections using <b>diagnostic equipment and software</b>
E-26.04.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-26.04.06P	select replacement <b>security and surveillance system components</b>	OEM or equivalent replacement <b>security and surveillance system components</b> are selected
E-26.04.07P	replace defective <b>security and surveillance system components</b>	defective <b>security and surveillance system components</b> are replaced
E-26.04.08P	program and configure <b>security and surveillance system</b>	<b>security and surveillance system</b> is programmed and configured according to job and facility requirements
E-26.04.09P	clean and adjust <b>security and surveillance system components</b>	<b>security and surveillance system components</b> are cleaned, adjusted and function according to location conditions and facility requirements
E-26.04.10P	update <b>documentation</b> to reflect testing, inspections and maintenance performed	<b>documentation</b> is clear, detailed and includes <b>security and surveillance systems</b> and <b>security and surveillance system components</b> tested, test results and changes completed
E-26.04.11P	notify and explain system changes to system monitor	system changes are explained to system monitor

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**security and surveillance systems** include: perimeter, space, spot

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**documentation** includes: maintenance logs, as-builts, latest inspection report

**security and surveillance system components** include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognition, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs

**diagnostic equipment and software** includes: multimeters, voltage testers, network cable analyzers, internal diagnostic software

Knowledge		
	Learning Outcomes	Learning Objectives
E-26.04.01L	demonstrate knowledge of <b>security and surveillance systems</b> and <b>security and surveillance system components</b> , their characteristics, applications and operation	identify types of <b>security and surveillance systems</b> , and describe their characteristics, applications and operation
		interpret information found on drawings and specifications
		interpret codes and regulations pertaining to <b>security and surveillance systems</b>
		identify <b>security and surveillance system components</b> , and describe their characteristics and applications
		identify considerations and requirements for selecting <b>security and surveillance systems</b> and <b>security and surveillance system components</b>
		describe types of <b>associated systems</b> that interconnect with <b>security and surveillance systems</b>
		describe possible effects of <b>security and surveillance system</b> maintenance on <b>associated systems</b>
E-26.04.02L	demonstrate knowledge of procedures to maintain <b>security and surveillance systems</b> and <b>security and surveillance system components</b>	identify tools and equipment used to maintain <b>security and surveillance systems</b> and <b>security and surveillance system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>security and surveillance systems</b> and <b>security and surveillance system components</b>

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describe procedures for testing **security and surveillance systems, security and surveillance system components** and **cables**

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describe procedures for commissioning and verification of **security and surveillance systems**

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## Range of Variables

**security and surveillance systems** include: perimeter, space, spot

**security and surveillance system components** include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs

**associated systems** include: central alarm monitoring, automatic doors, LAN, building automation systems, lighting

**cables** include: fibre optic, structured/category (category 5e, 6, 6A, 8), coaxial, twisted pairs, extra-low-voltage (LVT, ELC), shielded pairs, triads, quads

## Task E-27 Installs and maintains communication systems

### Task Descriptor

Communication systems allow information to be transmitted by voice, sound, lighting and data from one point to another, using wireless and structured cabling, which includes fiber optic, copper and coaxial cables. These types of systems may include Class 1 and Class 2 circuits, low-voltage power circuit, extra-low-voltage power circuit or low-energy power circuit. They include voice/data/video (VDV), voice over Internet protocol (VoIP), closed circuit television (CCTV), public address (PA), intercom, and various other industrial data communication systems.

Industrial data communication systems such as DeviceNet, Ethernet, Modbus are prevalent in the control environment for industrial electricians. Modbus is typically found on existing systems while newer systems use DeviceNet and Ethernet. Wireless technology is also becoming prevalent.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### E-27.01 Installs communication systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

Performance Criteria		Evidence of Attainment
E-27.01.01P	determine type of <b>communication system</b> required	type of <b>communication system</b> is determined according to electrical drawings, specifications, and job and facility requirements
E-27.01.02P	select tools and equipment	tools and equipment are selected according to task
E-27.01.03P	determine <b>communication system</b> layout	<b>communication system</b> layout is determined according to drawings, and job and facility requirements
E-27.01.04P	select <b>communication system components</b>	<b>communication system components</b> are selected according to electrical drawings, specifications, and job and facility requirements
E-27.01.05P	position, mount and assemble <b>communication system components</b>	<b>communication system components</b> are positioned, mounted and assembled in locations according to electrical drawings, manufacturers’ specifications, and job and facility requirements

E-27.01.06P	terminate and interconnect <b>communication system components</b> and <b>associated systems</b>	<b>communication system components</b> and <b>associated system</b> are terminated and interconnected according to electrical drawings, manufacturers' specifications, and job and AHJ requirements
E-27.01.07P	test cables for continuity, polarity, opens and grounds	voice data and video data wiring are tested ensuring cables have no opens and all <b>communication system components</b> are bonded to ground
E-27.01.08P	program and configure <b>communication system</b>	<b>communication system</b> is programmed and configured according to manufacturers' specifications, and job and facility requirements
E-27.01.09P	determine and configure device address	devices are addressed to enable communication and not interfere with existing systems
E-27.01.10P	remove and dispose of or recycle existing <b>communication system components</b> and update documentation	<b>communication system components</b> are disposed of or recycled according to local codes and waste disposal requirements, and documentation updated
E-27.01.11P	conduct initial <b>communication system</b> tests	sensory and spot tests are performed, and <b>communication system</b> tests are performed according to electrical drawings and specifications
E-27.01.12P	participate in startup/restart and commissioning inspections	devices are activated to trigger <b>events</b> , and <b>associated systems'</b> responses
E-27.01.13P	update <b>documentation</b>	<b>documentation</b> is updated to reflect commissioning activities

## Range of Variables

**communication systems** include: VDV and CCTV systems (unshielded twisted pair [UTP], screened twisted pair [ScTP]), data cables, fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [DAS] [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

**communication system components** include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

**associated systems** include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA

**events** include: digital system logs, notifications, alarms

**documentation** includes: maintenance logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, manufacturers' certification, equipment log

## Knowledge

Learning Outcomes	Learning Objectives
E-27.01.01L demonstrate knowledge of <b>communication systems</b> and <b>communication system components</b> , their characteristics, applications, operation and interconnection	identify types of <b>communication systems</b> , and describe their characteristics, applications and operation
	interpret information found on drawings and specifications
	interpret codes, standards and regulations pertaining to <b>communication systems</b>
	describe types of <b>associated systems</b> that interconnect with <b>communication systems</b>
	identify <b>communication system components</b> , and describe their characteristics and applications
	identify considerations and requirements for selecting <b>communication systems</b> and <b>communication system components</b>
	describe possible effects of <b>communication system</b> maintenance on <b>associated systems</b>
E-27.01.02L demonstrate knowledge of procedures to install, configure, upgrade and connect <b>communication systems</b> and <b>communication system components</b>	identify tools and equipment used to install, configure, upgrade and connect <b>communication systems</b> and <b>communication system components</b> , and describe their applications and procedures for use
	describe procedures to install, configure, upgrade and connect <b>communication systems</b> and <b>communication system components</b>
	describe procedures for testing <b>communication systems</b> and <b>communication system components</b>
	describe procedures for commissioning and verification of <b>communication systems</b>

## Range of Variables

**communication systems** include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

**associated systems** include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA

**communication system components** include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

**diagnostic and test equipment** includes: TDRs, optical time-domain reflectometer (OTDRs), cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters

### E-27.02 Maintains communication systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-27.02.01P	select tools and equipment	tools and equipment are selected according to task
E-27.02.02P	identify existing <b>communication systems</b> and <b>communication system components</b>	existing <b>communication systems</b> and <b>communication system components</b> are identified according to <b>documentation</b>
E-27.02.03P	obtain detailed description of malfunction or maintenance requirements	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
E-27.02.04P	test <b>communication systems</b>	tests are performed according to sensory inspections and technical inspections using <b>diagnostic and test equipment</b>
E-27.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-27.02.06P	replace <b>communication system components</b>	replacement <b>communication system components</b> are tested and verified

E-27.02.07P	update <b>documentation</b> to reflect testing, inspections or maintenance performed	<b>documentation</b> is clear and detailed and includes <b>communication systems</b> and <b>communication system components</b> tested, test results and changes completed
E-27.02.08P	notify and explain system changes to facility representatives or personnel	facility representatives or personnel are informed of system changes according to notification process and chain of command

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**communication systems** include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling), Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

**communication system components** include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

**diagnostic and test equipment** includes: TDRs, OTDRs, cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters, network analyzer

**documentation** includes: maintenance logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, manufacturers' certification, equipment log

## Knowledge

	Learning Outcomes	Learning Objectives
E-27.02.01L	demonstrate knowledge of <b>communication systems</b> and <b>communication system components</b> , their characteristics, applications, operation and interconnection	identify types of <b>communication systems</b> , and describe their characteristics, applications and operation
		interpret information found on drawings and specifications
		interpret codes, standards and regulations pertaining to <b>communication systems</b>
		identify <b>communication system components</b> , and describe their characteristics and applications



		describe types of <b>associated systems</b> that interconnect with <b>communication systems</b>
		describe possible effects of <b>communication systems</b> and maintenance on <b>associated systems</b>
E-27.02.02L	demonstrate knowledge of procedures to maintain <b>communication systems</b> and <b>communication system components</b>	identify tools and equipment used to maintain <b>communication systems</b> and <b>communication system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>communication systems</b> and <b>communication system components</b>
		describe procedures for testing <b>communication systems</b> , <b>communication system components</b> and cables
		describe procedures for verification of <b>communication systems</b>

## Range of Variables

**communication systems** include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

**associated systems** include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA

**communication system components** include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

**diagnostic and test equipment** includes: TDRs, OTDRs, cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters, network analyzer

## Task E-28 Installs and maintains building automation systems

### Task Descriptor

Building automation systems include integrated and environmental control systems.

Systems such as HVAC, fire alarm, lighting and security and other associated systems are interconnected through a building automation system that may signal or control the different building systems.

Building automation systems may also be integrated with automated control systems or may be stand alone. Building automation systems are also becoming integrated with personal communication devices.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspections, preventive/predictive maintenance, troubleshooting, replacing and repairing activities.

### E-28.01 Installs building automation systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-28.01.01P	determine type of <b>building automation system</b> required	type of <b>building automation system</b> is determined according to drawings, specifications, and job and facility requirements
E-28.01.02P	determine <b>building automation system</b> layout	<b>building automation system</b> layout is determined according to drawings, specifications, location visit, and job and facility requirements
E-28.01.03P	select <b>building automation system components</b>	<b>building automation system components</b> are selected according to drawings, specifications, and job and facility requirements
E-28.01.04P	select tools and equipment	tools and equipment are selected according to task
E-28.01.05P	position, mount and assemble <b>building automation system components</b>	<b>building automation system components</b> are positioned, mounted and assembled in locations according to drawings, specifications, and job and facility requirements
E-28.01.06P	terminate and interconnect <b>building automation system components</b> and <b>associated systems</b>	<b>building automation system components</b> and <b>associated systems</b> are terminated and interconnected according to drawings, specifications, and AHJ requirements

E-28.01.07P	test <b>building automation system components</b> to ensure functionality	<b>building automation system components</b> function as required
E-28.01.08P	test cables for opens and ground continuity	cables are tested and have no opens, and all <b>building automation system components</b> are bonded to ground
E-28.01.09P	test <b>building automation system</b>	<b>building automation system</b> tests are performed according to drawings and specifications
E-28.01.10P	remove and dispose of or recycle existing <b>building automation system</b> and <b>building automation system components</b>	<b>building automation system</b> and <b>building automation system components</b> are disposed of or recycled according to local codes and waste disposal requirements
E-28.01.11P	participate in startup, restart and commissioning	<b>building automation system components</b> are activated to trigger functionality of <b>building automation system</b> and <b>associated systems</b>
E-28.01.12P	update <b>documentation</b>	<b>documentation</b> is updated according to commissioning

## Range of Variables

**building automation systems** include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and direct digital control (DDC), computer control

**building automation system components** include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, Power over Ethernet (PoE) switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches

**associated systems** include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, supervisory, SCADA, PLC

**documentation** includes: as-built drawings, panel schedules, commissioning documents, manufacturers' specifications

## Knowledge

	Learning Outcomes	Learning Objectives
E-28.01.01L	demonstrate knowledge of <b>building automation systems</b> and <b>building automation system components</b> , their characteristics, applications, operation and interconnection	identify types of <b>building automation systems</b> , and describe their characteristics, applications and operation
		interpret information pertaining to <b>building automation systems</b> found on drawings and specifications
		interpret standards pertaining to <b>building automation systems</b>

		identify <b>building automation system components</b> , and describe their characteristics and applications
		describe types of <b>associated systems</b> that interconnect with <b>building automation systems</b>
		identify considerations and requirements for selecting <b>building automation systems</b> and <b>building automation system components</b>
E-28.01.02L	demonstrate knowledge of procedures to install <b>building automation systems</b> and <b>building automation system components</b>	identify tools and equipment used to install <b>building automation systems</b> and <b>building automation system components</b> , and describe their applications and procedures for use
		describe procedures to install <b>building automation systems</b> and <b>building automation system components</b>
		describe procedures for testing <b>building automation systems</b> and <b>building automation system components</b>
		describe procedures for commissioning and verification of <b>building automation systems</b> and <b>building automation system components</b>

## Range of Variables

**building automation systems** include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control

**building automation system components** include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches

**associated systems** include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, SCADA, PLC

## E-28.02 Maintains building automation systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
E-28.02.01P	obtain detailed description of malfunction or maintenance requirements	malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
E-28.02.02P	identify <b>building automation system</b> and <b>building automation system components</b>	<b>building automation system</b> and <b>building automation system components</b> are identified according to <b>documentation</b>
E-28.02.03P	select tools and equipment	tools and equipment are selected according to task
E-28.02.04P	test <b>building automation system</b>	<b>building automation system</b> is tested and system activation performed
E-28.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-28.02.06P	adjust <b>building automation system components</b>	<b>building automation system components</b> are adjusted to optimize performance
E-28.02.07P	replace <b>building automation system components</b>	replacement of <b>building automation system components</b> is scheduled with facility and local monitoring station, and replacement components are tested and verified
E-28.02.08P	update <b>documentation</b>	<b>documentation</b> is updated to reflect testing, inspections and maintenance performed
E-28.02.09P	notify and explain system changes	system changes are explained to system operator

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**building automation systems** include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control

**building automation system components** include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches

**documentation** includes: maintenance logs, digital back-up logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, manufacturers' specifications

Knowledge		
	Learning Outcomes	Learning Objectives
E-28.02.01L	demonstrate knowledge of <b>building automation systems</b> and <b>building automation system components</b> , their characteristics, applications, operation and interconnection	identify types of <b>building automation systems</b> , and describe their characteristics, applications and operation
		interpret information pertaining to <b>building automation systems</b> found on drawings and specifications, and manufacturer's documentation
		interpret <b>standards</b> pertaining to <b>building automation systems</b>
		identify <b>building automation system components</b> , and describe their characteristics and applications
		describe types of <b>associated systems</b> that interconnect with <b>building automation systems</b>
		identify considerations and requirements for selecting <b>building automation systems</b> and <b>building automation system components</b>
E-28.02.02L	demonstrate knowledge of procedures to maintain <b>building automation systems</b>	identify tools and equipment used to maintain <b>building automation systems</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>building automation systems</b> and <b>building automation system components</b>

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describe procedures for testing **building automation systems, building automation system components** and **cables**

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describe procedures for commissioning and verification of **building automation systems**

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## Range of Variables

**building automation systems** include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control

**standards** include: American National Standards Institute (ANSI)/ASHRAE 135 (BACnet), UL 916, ANSI/Telecommunications Industry Association (TIA) 862

**building automation system components** include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches

**associated systems** include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, SCADA, PLC

**cables** include: fibre optic, category/structure (category 5e, 6, 6A, 8), coaxial, twisted pairs, extra-low-voltage (LVT, ELC), shielded pairs, tri-ads, quads

# Major Work Activity F

## Installs and maintains process control systems

### Task F-29 Installs and maintains input/output (I/O) devices

#### Task Descriptor

I/O devices are used in control systems. There may be discrete or analog devices. Industrial electricians must be able to install, maintain and upgrade these devices.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

#### F-29.01 Installs discrete input/output (I/O) devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

#### Skills

	Performance Criteria	Evidence of Attainment
F-29.01.01P	visually inspect equipment to be installed	equipment to be installed is checked for damage and nameplate data matches drawings
F-29.01.02P	locate discrete <b>I/O devices</b>	discrete <b>I/O devices</b> are located by reading and interpreting prints, manufacturers' specifications, manuals and codes
F-29.01.03P	select tools and equipment	tools and equipment are selected according to application, manufacturers' specifications and compatible components
F-29.01.04P	mount discrete <b>I/O devices</b>	discrete <b>I/O devices</b> are mounted using various <b>methods</b> and according to manufacturers' specifications



F-29.01.05P	connect grounding, shielding and cabling	grounding, shielding and cabling are connected according to drawings, manufacturers' specifications, facility requirements and codes
F-29.01.06P	ensure polarity of conductors to field devices	polarity of conductors to field devices is ensured using multimeter, plans and manufacturers' specifications
F-29.01.07P	ensure calibration parameters match external devices	calibration parameters match installation requirements of external devices
F-29.01.08P	commission discrete <b>I/O devices</b>	discrete <b>I/O devices</b> are commissioned according to plans and manufacturers' specifications
F-29.01.09P	produce as-built drawings	as-built drawings are produced according to field installation and facility policy
F-29.01.10P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**input (I) devices** include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start stations

**output (O) devices** include: solenoid valves, relays, indicator light

**methods** include: bolting, welding, threading

Knowledge		
	Learning Outcomes	Learning Objectives
F-29.01.01L	demonstrate knowledge of <b>discrete control devices</b> , their characteristics, applications and operation	identify hazards and describe safe work practices pertaining to installation of <b>discrete control devices</b>
		interpret information pertaining to <b>discrete control devices</b> found on drawings and specifications
		explain use of discrete versus analog devices
		identify types of <b>discrete control devices</b> and describe their characteristics, applications and operation
		identify discrete control device components and accessories, and describe their characteristics and applications
		identify types of <b>voltage used with discrete devices</b> , and describe its characteristics, applications and operation
		explain use of <b>discrete control devices</b> for <b>measurement</b>

		identify considerations and requirements for selecting <b>discrete control devices</b> , their components and accessories
F-29.01.02L	demonstrate knowledge of procedures to install, connect and calibrate <b>discrete control devices</b> , and their components and accessories	identify tools and equipment used to install, connect and calibrate <b>discrete control devices</b> , and their components and accessories, and describe their applications and procedures for use
		describe procedures to install, connect and set <b>discrete control devices</b> , and their components and accessories
		describe procedures to calibrate <b>discrete control devices</b>

### Range of Variables

**discrete control devices** include: on-off control, counters and totalizers, timers, relays, pressure, temperature, level, flow

**voltage used with discrete device** includes: DC or AC voltage

**measurement** includes: pressure, temperature, flow, level, mass, density

## F-29.02 Maintains discrete input/output (I/O) devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-29.02.01P	select tools and equipment	tools and equipment are selected according to task
F-29.02.02P	detect <b>defects</b> in discrete <b>I/O device</b>	<b>defects</b> in <b>I/O device</b> are detected by monitoring controller
F-29.02.03P	perform sensory inspection of <b>components</b>	<b>components</b> are inspected for damage, wear, misalignment and loose connection according to scheduled maintenance requirements
F-29.02.04P	review and analyze trends from discrete <b>I/O device</b> signal	trends from discrete <b>I/O device</b> signal are reviewed and analyzed to verify integrity of signal
F-29.02.05P	check and set power supply voltages	power supply voltages are checked and set according to plans and manufacturers' specifications
F-29.02.06P	calibrate <b>discrete I/O devices</b>	<b>discrete I/O devices</b> are calibrated according to drawings, manufacturers' specifications and facility requirements, and documented as found or as left

F-29.02.07P	perform I/O function test on discrete device	I/O function test is performed on discrete device for verifying operation according to plans and manufacturers' specifications
F-29.02.08P	verify operation of <b>discrete I/O devices</b>	operation of <b>discrete I/O device</b> is verified following maintenance according to process parameters
F-29.02.09P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**defects** include: corrosion, loose connection, mechanical damage, wear

**input (I) devices** include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start stations

**output (O) devices** include: solenoid valves, relays, indicator light

**components** for inspection include: limit switches, photocells, transmitters

**discrete I/O devices** include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start station

## Knowledge

	Learning Outcomes	Learning Objectives
F-29.02.01L	demonstrate knowledge of <b>discrete control devices</b> , their characteristics, applications and operation	identify hazards and describe safe work practices pertaining to <b>discrete control devices</b>
		interpret information pertaining to <b>discrete control devices</b> found on drawings and specifications
		explain use of discrete versus analog devices
		identify types of <b>discrete control devices</b> , and describe their characteristics, applications and operation
		identify <b>discrete control device</b> components and accessories, and describe their characteristics and applications
		identify type of <b>voltage used with discrete devices</b> , and describe its characteristics, applications and operation
		explain use of <b>discrete control devices</b> for <b>measurement</b>
		identify considerations and requirements for selecting <b>discrete control devices</b> , their components and accessories

F-29.02.02L	demonstrate knowledge of procedures to maintain and test <b>discrete control devices</b> , their components and accessories	identify tools and equipment used to maintain and test <b>discrete control devices</b> , their components and accessories, and describe their applications and procedures for use
		describe procedures to maintain <b>discrete control devices</b> , their components and accessories
		describe procedures to repair and test <b>discrete control devices</b> , their components and accessories

## Range of Variables

**discrete control devices** include: on-off control, counters and totalizers, timers, relays, pressure, temperature, level, flow

**voltage used with discrete device** includes: DC or AC voltage

**measurement** includes: pressure, temperature, flow, level, mass, density

## F-29.03 Installs analog input/output (I/O) devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-29.03.01P	visually inspect equipment to be installed	equipment to be installed is checked for damage and nameplate data matches drawings
F-29.03.02P	locate analog <b>I/O devices</b>	analog <b>I/O devices</b> are located by reading and interpreting prints, manufacturers' manuals and codes
F-29.03.03P	select tools and equipment	tools and equipment are selected according to application, manufacturers' specifications and compatible components
F-29.03.04P	mount <b>I/O devices</b>	<b>I/O devices</b> are mounted using various <b>methods</b> and according to manufacturers' specifications
F-29.03.05P	connect grounding, shielding and cabling	grounding, shielding and cabling are connected according to manufacturers' specifications, and facility and CEC requirements
F-29.03.06P	ensure polarity of conductors to field devices	polarity of conductors to field devices is ensured using multimeter, plans and manufacturers' specifications

F-29.03.07P	configure device	device is configured by setting range according to plans and manufacturers' specifications
F-29.03.08P	ensure calibration parameters for external devices	calibration parameters are matched to installation requirements
F-29.03.09P	calibrate analog device	analog device is calibrated according to plans and manufacturers' specifications
F-29.03.10P	commission analog devices, and modify settings	analog devices are commissioned and settings are modified according to plans and manufacturers' specifications
F-29.03.11P	produce as-built drawings	as-built drawings are produced according to field installation and facility policy
F-29.03.12P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**input (I) devices** include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, encoders, tachometers

**output (O) devices** include: proportional valves, linear actuators, solenoid valves

**methods** include: bolting, welding, threading

Knowledge		
	Learning Outcomes	Learning Objectives
F-29.03.01L	demonstrate knowledge of <b>analog control devices</b> , their characteristics, applications and operation	identify hazards and describe safe work practices
		interpret information found on drawings and specifications
		differentiate between use of analog versus discrete devices
		identify types of <b>analog control devices</b> , and describe their characteristics, applications and operation
		identify analog control device components and accessories, and describe their characteristics and applications
		identify types of <b>signals used with analog devices</b> , and describe their characteristics, applications and operation
		explain use of <b>analog control devices for measurement</b>
		identify considerations and requirements for selecting <b>analog control devices</b> , their components and accessories

F-29.03.02L	demonstrate knowledge of procedures to install, connect and calibrate <b>analog control devices</b>	identify tools and equipment used to install, connect and calibrate <b>analog control devices</b> , and describe their applications and procedures for use
		describe procedures to install and connect <b>analog control devices</b> , their components and accessories
		describe procedures to calibrate <b>analog control devices</b>

## Range of Variables

**analog control devices** include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, proportional valves, linear actuators, solenoid valves, transducers

**signals used with analog devices** include: resistance, current, voltage (sinking or sourcing)

**measurement** includes: pressure, temperature, flow, level, mass, density

## F-29.04 Maintains analog input/output (I/O) devices

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-29.04.01P	perform sensory inspection of <b>components</b>	<b>components</b> are inspected for damage, wear, misalignment and loose connection
F-29.04.02P	select tools and equipment	tools and equipment are selected according to task
F-29.04.03P	detect <b>defects</b> in analog <b>I/O device</b>	<b>defects</b> in <b>I/O device</b> are detected by monitoring controller according to repair request or scheduled maintenance
F-29.04.04P	review and analyze trends from input device signal	trends from input device signal are reviewed and analyzed to verify integrity of signal
F-29.04.05P	calibrate analog <b>I/O devices</b>	analog <b>I/O devices</b> are calibrated according to drawings, manufacturers' specifications and facility requirements, and document as found/as left
F-29.04.06P	verify operation of analog <b>I/O devices</b>	operation of analog <b>I/O devices</b> is verified following service according to process parameters
F-29.04.07P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**components** for inspection include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, proportional valves, linear actuators, solenoid valves

**defects** include: corrosion, loose connections, mechanical damage, wear

**input (I) devices** include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, encoders, tachometers

**output (O) devices** include: proportional valves, linear actuators, solenoid valves

Knowledge		
	Learning Outcomes	Learning Objectives
F-29.04.01L	demonstrate knowledge of <b>analog control devices</b> , their characteristics, applications and operation	identify hazards and describe safe work practices
		interpret information found on drawings and specifications
		differentiate between use of analog versus discrete devices
		identify types of <b>analog control devices</b> and describe their characteristics, applications and operation
		identify analog control device components and accessories, and describe their characteristics and applications
		identify types of <b>signals used with analog devices</b> , and describe their characteristics, applications and operation
		explain use of <b>analog control devices for measurement</b>
F-29.04.02L	demonstrate knowledge of procedures to maintain and test <b>analog control devices</b> , their components and accessories	identify tools and equipment used to maintain and test <b>analog control devices</b> , their components and accessories, and describe their applications and procedures for use
		describe procedures to maintain <b>analog control devices</b> , their components and accessories
		describe procedures to test <b>analog control devices</b> , their components and accessories

## Range of Variables

**analog control devices** include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, proportional valves, linear actuators, solenoid valves, transducers

**signals used with analog devices** include: resistance, current, voltage (sinking or sourcing)

## Task F-30 Installs, programs and maintains automated control systems

### Task Descriptor

In industrial, manufacturing or utility environments, processes require control and the ability to interface with other systems. These controls can be complex automated systems. Automated control systems are often programmable systems such as PLC and DCS.

The operator interfaces for many of these systems have migrated from physical hardware to GUI such as HMIs. As a result, the electrical work pertaining to the I/O devices has become software based.

Automated control systems may also be integrated with Building Automation Systems.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### F-30.01 Installs automated control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-30.01.01P	determine type and function of <b>automated control system</b>	<b>automated control system</b> is selected according to application
F-30.01.02P	calculate conductor and cabling requirements	conductor and cable type and size are calculated according to application, codes and manufacturers' specifications
F-30.01.03P	select tools and equipment	tools and equipment are selected according to task
F-30.01.04P	position, mount and assemble <b>automated control system</b>	<b>automated control system</b> is positioned, mounted and assembled in locations according to drawings, and job and facility requirements; is level, square, and secure, and follows building lines



F-30.01.05P	configure automated control systems hardware	automated control system hardware is configured by ensuring dip switches, keying and jumpers are in required position according to drawings and manufacturers' specifications
F-30.01.06P	bond <b>automated control systems</b>	<b>automated control systems</b> are bonded according to codes and manufacturers' specifications
F-30.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers specifications, and AHJ, CSA and CEC requirements
F-30.01.08P	set up and adjust <b>automated control systems</b>	<b>automated control systems</b> are set up and adjusted according to CEC requirements, application and intended function
F-30.01.09P	interconnect and configure <b>automated control systems</b> with <b>peripheral devices</b>	<b>automated control systems</b> are interconnected with <b>peripheral devices</b> and equipment functions as intended
F-30.01.10P	test <b>automated control systems</b> after installation	<b>automated control systems</b> are connected and function according to manufacturers' specifications and facility requirements, and results are documented
F-30.01.11P	update documentation	operational changes are reflected in drawings following removal or replacement of equipment which is performed with minimal impact to environment

## Range of Variables

**automated control systems** include: PLC, SCADA system, DCS, DNP

**peripheral devices** of automated control systems include: HMI (touchscreen and discrete buttons), displays, keyboard, mouse, printers

Knowledge		
	Learning Outcomes	Learning Objectives
F-30.01.01L	demonstrate knowledge of <b>automated control systems</b> and <b>automated control system components</b> , their characteristics, applications, operation and interconnections	identify types of <b>automated control systems</b> , and describe their characteristics, applications, operation and interconnections
		identify <b>automated control system components</b> , and describe their purpose and operation
		interpret information found on drawings and specifications

		interpret codes and regulations pertaining to <b>automated control systems</b>
		identify sources of information pertaining to <b>automated control system</b> installation, configuration and programming
		identify <b>number systems</b> and <b>code systems</b> , and describe their applications
		perform conversions between <b>number systems</b>
		explain and interpret <b>control circuit logic</b>
F-30.01.02L	demonstrate knowledge of <b>automated control system data communication systems</b> and <b>automated control system components</b>	identify types of <b>automated control system data communication systems</b> , and describe their characteristics, applications and operation
		identify automated control system data communication system components, and describe their characteristics, applications and operation
		identify <b>devices</b> used to communicate with interconnected <b>automated control systems</b>
F-30.01.03L	demonstrate knowledge of procedures to install and connect <b>automated control systems</b> and <b>automated control system components</b>	identify tools and equipment used to install and connect <b>automated control systems</b> and <b>automated control system components</b> , and describe their applications and procedures for use
		describe procedures to install <b>automated control systems</b> and <b>automated control system components</b>
		describe procedures to connect <b>automated control systems</b> and <b>automated control system components</b>

## Range of Variables

**automated control systems** include: PLC, SCADA system, DCS, DNP

**automated control system components** include: hardware (power supply, central processing unit [CPU], I/O system, programming terminals), software

**number systems** include: binary, decimal, hexadecimal, octal

**code systems** include: binary coded decimal (BCD), American Standard Code for Information Interchange (ASCII)

**control circuit logic** includes: relay logic, ladder logic, function block, text based

**automated control system data communication systems** include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet, IEC

**devices** include: handheld mobile (tablet), computer, HMI

## F-30.02 Maintains automated control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-30.02.01P	obtain detailed description of operation and malfunction or scheduled maintenance requirements	operation, malfunction issues and <b>information</b> are obtained from <b>facility sources</b> and documented
F-30.02.02P	select tools and equipment	tools and equipment are selected according to task
F-30.02.03P	determine source of malfunction	source of malfunction is determined according to <b>field assessments</b> and <b>diagnostic and test equipment</b> results
F-30.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
F-30.02.05P	repair and test malfunctioning components	components are repaired and tested according to manufacturers' specifications
F-30.02.06P	select replacement components	OEM or equivalent replacement components are selected
F-30.02.07P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions, and according to manufacturers' specifications and facility policy
F-30.02.08P	conduct tests of <b>automated control systems</b>	<b>automated control systems</b> are tested after repair, connected and function according to manufacturers' specifications and facility requirements
F-30.02.09P	<b>inspect, clean and adjust</b> components	automated control systems are <b>inspected, cleaned and adjusted</b> to restore to optimal conditions and according to manufacturers' specifications
F-30.02.10P	complete backups and document tests in maintenance log	operational problems and test results are identified in maintenance log
F-30.02.11P	archive and update firmware	firmware is archived and updated according to manufacturers' specifications and facility requirements
F-30.02.12P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and specifications

## Range of Variables

**information** includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

**field assessments** include: sensory inspections, technical inspections

**diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters, handheld programmers, computer, network analyzer

**automated control systems** include: PLC, SCADA system, DCS, DNP

**inspect, clean and adjust** includes: inspecting terminations, cleaning fans and filters, adjusting access openings and sealing, cleaning sensors

Knowledge		
	Learning Outcomes	Learning Objectives
F-30.02.01L	demonstrate knowledge of <b>automated control systems</b> and <b>automated control system components</b> , their characteristics, applications, operation and interconnections	identify types of <b>automated control systems</b> , and describe their characteristics, applications, operation and interconnections
		identify <b>automated control system components</b> , and describe their purpose and operation
		interpret information found on drawings and specifications
		interpret codes and regulations pertaining to <b>automated control systems</b>
		identify sources of information pertaining to <b>automated control system</b> service, maintenance, troubleshooting and configuration
		identify <b>number</b> and <b>code systems</b> , and describe their applications
		perform conversions between <b>number systems</b>
		explain and interpret <b>control circuit logic</b>
		describe basic Proportional-Integral-Derivative (PID) control theory
		describe <b>basic process control theory</b>
		identify <b>basic instruction sets for ladder logic</b> and <b>basic function block</b> , and describe their applications
F-30.02.02L	demonstrate knowledge of <b>automated control system data communication systems</b> and their components	identify types of <b>automated control system data communication systems</b> , and describe their characteristics, applications and operation

		identify automated control system data communication system components, and describe their characteristics, applications and operation
		identify <b>devices</b> used to communicate with interconnected <b>automated control systems</b>
F-30.02.03L	demonstrate knowledge of procedures for maintenance of <b>automated control systems</b> and <b>automated control system components</b>	identify tools and equipment used to maintain <b>automated control systems</b> and <b>automated control system components</b> , and describe their applications and procedures for use
		describe procedures to maintain <b>automated control systems</b> and <b>automated control system components</b>

## Range of Variables

**automated control systems** include: PLC, SCADA system, DCS, DNP

**automated control system components** include: hardware (power supply, CPU, I/O system, programming terminals), software

**number systems** include: binary, decimal, hexadecimal, octal

**code systems** include: BCD, ASCII, gray code

**control circuit logic** includes: relay logic, ladder logic, function block

**automated control system data communication systems** include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, IEC

**devices** include: handheld mobile (tablet), computer, HMI

**basic instruction sets for ladder logic** include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

**basic function block** includes: input block, control block and output block

**basic process control theory** includes: control loops, control modes, loop tuning

## F-30.03 Programs automated control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-30.03.01P	map <b>inputs and outputs</b>	<b>inputs and outputs</b> are mapped using manufacturers' software to meet process requirements
F-30.03.02P	set address <b>variables</b>	address <b>variables</b> are set for internal instructions according to application

F-30.03.03P	write or edit and verify automated control program	automated control program is written, edited and verified to operate according to specified logic
F-30.03.04P	back-up and document program changes	program changes are backed-up and documented according to facility policy
F-30.03.05P	set parameters for automated control program	technical and operating parameters are set according to installation and operation requirements
F-30.03.06P	test and adjust automated control program	operation of system is tested and adjusted according to design and facility requirements

## Range of Variables

**inputs and outputs** include: direct address, tag-based address

**variables** include: timers, counters, blocks, registers, tables

Knowledge		
	Learning Outcomes	Learning Objectives
F-30.03.01L	demonstrate knowledge of <b>automated control systems</b> , their characteristics, applications, operation and interconnection	identify types of <b>automated control systems</b> , and describe their characteristics, applications, operation and interconnections
		explain differences between PLC and DCS systems
		interpret codes and regulations pertaining to <b>automated control systems</b>
		identify <b>basic instruction sets for ladder logic</b> and <b>basic function block</b> , and describe their applications
		identify <b>number systems</b> and <b>code systems</b> , and describe their applications
		perform conversions between <b>number systems</b>
		explain and interpret <b>control circuit logic</b>
F-30.03.02L	demonstrate knowledge of <b>automated control system data communication systems</b> and their components	describe basic PID control theory
		identify types of <b>automated control system data communication systems</b> , and describe their characteristics, applications and operation
		compare and contrast types of <b>data communication systems</b>

F-30.03.03L	demonstrate knowledge of procedures for programming and configuring <b>automated control systems</b>	identify <b>devices</b> used to communicate with interconnected <b>automated control systems</b> , and describe procedures to perform programming, editing and configuration of <b>automated control systems</b> online and offline
		identify <b>automated control system</b> programming languages and describe their applications

## Range of Variables

**automated control systems** include: PLC, SCADA system, DCS, DNP

**automated control system data communication systems** include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, IEC

**basic instruction sets for ladder logic** include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

**basic function block** includes: input block, control block and output block

**number systems** include: binary, decimal, hexadecimal, octal

**code systems** include: BCD, ASCII, gray code

**control circuit logic** includes: relay logic, ladder logic, function block, text based

**devices** include: handheld mobile (tablet), computer, HMI

## F-30.04 Optimizes system performance

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-30.04.01P	ensure version of manufacturers' manual matches version of manufacturers' software	version of manufacturers' software is matched to manufacturers' manual
F-30.04.02P	archive and update firmware	firmware is archived and updated to facilitate system operation according to manufacturers' specifications and facility requirements
F-30.04.03P	review and modify existing program and system parameters	program (machine cycle time and scan time) and system parameters are reviewed and modified to match changes of process, and to ensure efficiency of program
F-30.04.04P	ensure sequential programming logic	sequential programming logic is ensured to optimize scan time

F-30.04.05P	test run program	program is executed in test mode to verify intended operation and optimization
F-30.04.06P	tune control loops	control loops are tuned to optimize process
F-30.04.07P	back-up and document program changes	program changes are backed-up and documented according to facility policy

## Knowledge

Learning Outcomes	Learning Objectives	
F-30.04.01L	demonstrate knowledge of <b>automated control systems</b> , their characteristics, applications and operation	identify types of <b>automated control systems</b> , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to <b>automated control systems</b>
		identify <b>number systems</b> and <b>code systems</b> , and describe their applications
		perform conversions between <b>number systems</b>
		explain and interpret <b>control circuit logic</b>
		describe basic PID control theory
F-30.04.02L	demonstrate knowledge of <b>automated control system data communication systems</b> and their components	describe <b>basic process control theory</b>
		identify <b>basic instruction sets for ladder logic</b> and <b>basic function block</b> , and describe their applications
		identify types of <b>automated control system data communication systems</b> , and describe their characteristics, applications and operation
F-30.04.03L	demonstrate knowledge of procedures for programming, configuring and optimizing <b>automated control systems</b>	identify automated control system data communication system components, and describe their characteristics, applications and operation
		identify <b>devices</b> used to communicate with interconnected <b>automated control systems</b> , and describe procedures to perform programming, editing, configuration, optimization and firmware updates of <b>automated control systems</b> online and offline
		identify automated control system programming languages and describe their applications



## Range of Variables

**automated control systems** include: PLC, SCADA system, DCS, DNP

**automated control system components** include: hardware (power supply, CPU, I/O system, programming terminals), software

**number systems** include: binary, decimal, hexadecimal, octal

**code systems** include: BCD, ASCII, gray

**control circuit logic** includes: relay logic, ladder logic, function block, text based

**automated control system data communication systems** include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, IEC

**devices** include: handheld mobile (tablet), computer, HMI

**basic instruction sets for ladder logic** include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

**basic function block** includes: input block, control block and output block

**basic process control theory** includes: control loops, control modes, loop tuning

## Task F-31 Installs and maintains pneumatic and hydraulic control systems

### Task Descriptor

Pneumatic and hydraulic equipment is used to supply energy and to control equipment and processes through the use of air, nitrogen, process gases and fluids. Industrial electricians install and maintain pneumatic and hydraulic control systems.

For the purpose of this standard, “install” includes both new installations and upgrading of existing systems by removing and replacing components.

For the purpose of this standard, “maintain” includes inspection, preventative/predictive maintenance, troubleshooting, replacing and repairing activities.

### F-31.01 Installs pneumatic control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-31.01.01P	determine location of pneumatic equipment	location of pneumatic equipment is determined according to plans, codes, facility policy and manufacturers' recommendations
F-31.01.02P	select tools and equipment	tools and equipment are selected according to task

F-31.01.03P	connect <b>pneumatic control system components</b>	<b>pneumatic control system components</b> are connected according to plans, codes and process requirements
F-31.01.04P	calibrate pneumatic control <b>devices</b>	pneumatic control <b>devices</b> are calibrated to process requirements
F-31.01.05P	verify operation of pneumatic control system	operation of pneumatic control system is verified by using test equipment and procedures to ensure it is within specified parameters
F-31.01.06P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**pneumatic control system components** include: regulators, separators, tubing, actuators, solenoids, pumps, positioners, accumulators, compressors, tanks, coolers, filters, dryers, automated oilers

**devices** include: pressure switches, regulators, gauges

Knowledge		
	Learning Outcomes	Learning Objectives
F-31.01.01L	demonstrate knowledge of <b>pneumatic control systems</b> and <b>pneumatic control system components</b> , their characteristics, applications and operation	identify types of <b>pneumatic control systems</b> and <b>pneumatic control system components</b> , and describe their characteristics, applications and operation
		interpret information pertaining to <b>pneumatic control system</b> devices found on drawings and specifications
		interpret <b>documentation</b> to determine operation of pneumatic control systems
F-31.01.02L	demonstrate knowledge of pneumatic related <b>calculations</b>	describe effects of and impacts of installation on pneumatic related <b>calculations</b>
F-31.01.03L	demonstrate knowledge of procedures to install <b>pneumatic control system equipment</b> and <b>pneumatic control system components</b>	identify tools and equipment used to install <b>pneumatic control system equipment</b> and <b>pneumatic control system components</b> , and describe their applications and procedures for use
		describe procedures to install <b>pneumatic control systems</b> and <b>pneumatic control system components</b>

## Range of Variables

**pneumatic control systems** include: instrument air, instrument gas

**pneumatic control system components** include: regulators, separators, tubing, actuators, solenoids, pumps, positioners, accumulators, compressors, tanks, coolers, filters, dryers, automated oilers

**documentation** includes: schematics, manufacturers' manuals

**calculations** include: signal conversion, unit conversion

## F-31.02 Maintains pneumatic control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-31.02.01P	select tools and equipment	tools and equipment are selected according to task
F-31.02.02P	test and verify control devices	control devices are tested and verified according to <b>system specifications</b>
F-31.02.03P	calibrate and adjust control devices	control devices are calibrated and adjusted according to <b>system specifications</b> and maintenance schedules
F-31.02.04P	change system <b>components and materials</b>	system <b>components and materials</b> are changed according to manufacturers' specifications and facility policy
F-31.02.05P	identify probable root cause and location of faults	probable root cause and location of faults are identified using diagnostic tools and testing procedures, speaking with <b>facility sources</b> and using maintenance documentation and historical data
F-31.02.06P	determine steps required to repair faults and address deficiencies	steps required to repair faults and address deficiencies are determined based on results of root cause analysis
F-31.02.07P	lock out and de-energize energy potential	lockout and de-energization are verified by performing a post-operational test to verify zero energy state and gravity (kinetic)
F-31.02.08P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures
F-31.02.09P	verify operation	operation is verified before returning to service
F-31.02.10P	document changes	changes are documented according to facility policy

### Range of Variables

**system specifications** include: pressure, flow

**components and materials** include: filters, drying systems, reservoirs, compressors

**facility sources** (for information) include: operators, maintenance personnel, supervisors, work order, other trades

## Knowledge

	Learning Outcomes	Learning Objectives
F-31.02.01L	demonstrate knowledge of <b>pneumatic control systems</b> and their components, applications and operation	interpret information found on drawings and specifications
		identify types of <b>pneumatic control systems</b> and their components, and describe their applications and operation
		interpret <b>documentation</b> to determine operation of pneumatic control systems
F-31.02.02L	demonstrate knowledge of pneumatic related <b>calculations</b>	describe effects of and impacts of maintenance on pneumatic related <b>calculations</b>
F-31.02.03L	demonstrate knowledge of procedures to maintain <b>pneumatic control systems</b> and their components	identify tools and equipment used to maintain <b>pneumatic control systems</b> and their components, and describe their applications and procedures for use
		describe procedures to maintain <b>pneumatic control systems</b> and their components

### Range of Variables

**pneumatic control systems** include: instrument air, instrument gas

**documentation** includes: schematics, manufacturers' manuals

**calculations** include: signal conversion, unit conversion

## F-31.03 Installs hydraulic control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

## Skills

	Performance Criteria	Evidence of Attainment
F-31.03.01P	select <b>hydraulic system control devices</b> and <b>hydraulic control system components</b>	<b>hydraulic system control devices</b> and <b>hydraulic control system components</b> are selected according to manufacturers' specifications, process requirements and codes
F-31.03.02P	select tools and equipment	tools and equipment are selected according to task
F-31.03.03P	determine location of <b>hydraulic system control devices</b>	location of <b>hydraulic system control devices</b> is determined according to codes, practices and manufacturers' recommendations

F-31.03.04P	connect <b>hydraulic system control devices</b> and <b>hydraulic control system components</b>	<b>hydraulic system control devices</b> and <b>hydraulic control system components</b> are connected using materials
F-31.03.05P	verify operation of hydraulic equipment and <b>hydraulic system control devices</b>	operation of hydraulic equipment and <b>hydraulic system control devices</b> are verified using test equipment and procedures to ensure they are within specified parameters
F-31.03.06P	update documentation	documentation is updated to reflect changes carried out

## Range of Variables

**hydraulic system control devices** include: solenoids, switches, actuators

**hydraulic control system components** include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

Knowledge		
	Learning Outcomes	Learning Objectives
F-31.03.01L	demonstrate knowledge of hydraulic control systems and <b>hydraulic control system components</b> , their applications and operation	identify types of hydraulic control systems and <b>hydraulic control system components</b> , and describe their applications and operation
		interpret information pertaining to <b>hydraulic system control devices</b> found on drawings and specifications
		interpret <b>documentation</b> to determine operation of hydraulic control systems
	demonstrate knowledge of procedures to install hydraulic control systems and <b>hydraulic control system components</b>	identify tools and equipment used to install hydraulic control systems and <b>hydraulic control system components</b> , and describe their applications and procedures for use
		describe procedures to install hydraulic control systems and <b>hydraulic control system components</b>

## Range of Variables

**documentation** includes: schematics, manufacturers' manuals

**hydraulic control system components** include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

## F-31.04 Maintains hydraulic control systems

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

### Skills

	Performance Criteria	Evidence of Attainment
F-31.04.01P	select tools and equipment	tools and equipment are selected according to task
F-31.04.02P	test and verify <b>hydraulic system control devices</b> and <b>hydraulic control system components</b>	<b>hydraulic system control devices</b> and <b>hydraulic control system components</b> are tested and verified according to <b>system specifications</b>
F-31.04.03P	calibrate and adjust <b>hydraulic system control devices</b> and <b>hydraulic control system components</b>	<b>hydraulic system control devices</b> and <b>hydraulic control system components</b> are calibrated and adjusted according to system specifications and maintenance schedules
F-31.04.04P	check fluid and filters	fluids and filters are checked according to manufacturers' specifications
F-31.04.05P	change <b>hydraulic control system components</b>	<b>hydraulic control system components</b> are changed according to manufacturers' specifications and facility policy
F-31.04.06P	identify probable root cause and location of faults	probable root cause and location of faults are identified using diagnostic tools and testing procedures, and referring to maintenance documentation and historical data
F-31.04.07P	determine steps required to repair faults and address deficiencies	steps required to repair faults and address deficiencies are determined according to results of root cause analysis
F-31.04.08P	lock out and de-energize energy potential	lockout and de-energization are verified by performing a post-operational test to verify zero energy state and gravity (kinetic)
F-31.04.09P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures
F-31.04.10P	verify operation	operation is verified before returning to service
F-31.04.11P	update maintenance log	maintenance log is updated to reflect tasks performed

## Range of Variables

**hydraulic system control devices** include: solenoids, switches, actuators

**system specifications** include: pressure, flow, temperature, level

**hydraulic control system components** include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

Knowledge		
	Learning Outcomes	Learning Objectives
F-31.04.01L	demonstrate knowledge of hydraulic control systems and <b>hydraulic control system components</b> , their applications and operation	identify types of hydraulic control systems and <b>hydraulic control system components</b> , and describe their applications and operation
		interpret information pertaining to <b>hydraulic system control devices</b> found on drawings and specifications
		interpret <b>documentation</b> to determine operation of hydraulic control systems
F-31.04.02L	demonstrate knowledge of procedures to maintain hydraulic control system equipment and <b>hydraulic control system components</b>	identify tools and equipment used to maintain hydraulic control system equipment and <b>hydraulic control system components</b> , and describe their applications and procedures for use
		describe procedures to maintain hydraulic control systems and <b>hydraulic control system components</b>

## Range of Variables

**hydraulic control system components** include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

**hydraulic system control devices** include: solenoids, switches, actuators

**documentation** includes: schematics, manufacturers' manuals

# APPENDIX A

## ACRONYMS

AC	alternating current
AED	automated external defibrillator
AFCI	arc fault circuit interrupter
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
AVR	Automatic Voltage Regulator
BCD	binary coded decimal
BIL	Basic Insulation Level
CAD	computer-aided design
CAM	computer-aided manufacturing
CCTV	closed-circuit television
CEC	Canadian Electrical Code
CPR	cardiopulmonary resuscitation
CPU	central processing unit
CSA	Canadian Standards Association
CSC	Construction Specifications Canada
CT	current transformer
DAS	distributed antenna system
DC	direct current
DCLA	data communication link, Class A
DCLB	data communication link, Class B
DCLC	data communication link, Class C
DCS	distributed control system
DDC	direct digital control
DNP	distributed network protocol
DVR	digital video recorder
ELV	extra-low-voltage
EMC	electro-magnetic compatibility
EMT	electrical metallic tubing
ENT	electrical non-metallic tubing
FLC	full load current
GFCI	ground fault circuit interrupter
GUI	graphical user interface
HDPE	high-density polyethylene
HID	high intensity discharge



HMI	human machine interfacing
HVAC	heating, ventilation and air-conditioning
I/O	input/output
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
kVA	kilovolt-amps
LAN	local area network
LED	light emitting diode
MCC	motor control centre
MOV	metal oxide varistor
NBC	National Building Code
NFC	National Fire Code of Canada
O&M	operations and maintenance
OEM	original equipment manufacturer
OH&S	Occupational Health and Safety
OTDR	optical time-domain reflectometer
PA	public address
PCB	polychlorinated biphenyl
PDC	power distribution centre
PID	proportional-integral-derivative
PLC	programmable logic controller
PoE	Power over Ethernet
PPE	personal protective equipment
PVC	Poly Vinyl Chloride
RFID	radio frequency identification
ScTP	screened twisted pair
SIS	safety instrumented systems
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheets
TDR	time-domain reflectometer
TIA	Telecommunications Industry Association
SPL	sound pressure level
SI	système internationale
TDG	Transportation of Dangerous Goods
ULC	Underwriters Laboratories of Canada
UPS	uninterruptible power supply
UTP	unshielded twisted pair
VA	volt-ampere
VDV	voice/data/video
VFD	variable frequency drive
VoIP	voice over Internet protocol

VT	voltage transformer (previously called potential transformer)
WHMIS	Workplace Hazardous Materials Information System
WLL	working load limit

# APPENDIX B

## TOOLS AND EQUIPMENT / OUTILS ET ÉQUIPEMENT

### Hand Tools / Outils à main

adjustable wrenches	clés ajustables
cable cutters (ratchet)	coupe-câbles (à rochet)
cable splice/stripper tools	outils à épisser et à dénuder les câbles
cable tie guns	pistolets pour attache-câbles
calculators	calculatrices
centre punches	pointeaux à centrer
chisels	ciseaux
cold chisels	ciseaux à froid
crimping pliers	pincés à sertir
diagonal cutting pliers	pincés à coupe diagonale
drill bits (auger, masonry, step and wood)	forets (hélicoïdaux, de maçonnerie, étagés et à bois)
files	limes
fish tapes	ruban de tirage
flashlights	lampes de poche
fuse pullers	arrache-fusibles
hacksaws	scies à métaux
hammers (ball pein, dead blow and rubber)	marteaux (à panne ronde, à amortisseur et en caoutchouc)
hex keys (metric/imperial)	clés hexagonales (métriques et impériales)
hole saws	scies emporte-pièces
hot sticks	perches isolantes
integrated circuit extractors	extracteurs pour circuits intégrés
jumpers cables/wires	câbles survolteurs et câbles de liaison
keyhole saws	scies à guichet
knives	couteaux
knock-out cutters	emporte-pièces
levels including torpedo	niveaux, y compris les niveaux à torpille
linesman pliers	pincés d'électricien
cable/wire pullers	tire-câbles
needle nose pliers	pincés à bec effilé
nipple chucks	mandrins à mamelons
nut drivers (metric/imperial)	tournevis à douille (métriques et impériaux)
picks	pioches
pipe benders and hickies	plieuses à tuyaux et cintreuses
pipe cutters	coupe-tuyaux

pipe reamers (hand and ratchet)	alésoirs à tuyaux (à main et à rochet)
pipe threaders	fileteuses de tuyaux
pipe wrenches	clés à tuyaux
punches	poinçons
PVC cutters	ciseaux pour le PVC
scrapers	grattoirs
screw starters	pose-vis
screwdrivers (flat, phillips, robertson and torx)	tournevis (plats, cruciformes, à pointe carrée et Torx)
scribes	pointes à tracer
side cutters	ciseaux à coupe latérale
slide lock pliers	pincés réglables
socket sets (metric/imperial)	jeux de douilles (métriques et impériales)
spline keys	clavettes
static discharge wristbands and anti-static mats	bracelets antidécharge d'électricité statique et tapis antistatiques
step drills	forets étagés
tape measures	rubans à mesurer
taps (metric/imperial) and dies	tarauds (métriques et impériaux) et matrices
telescopic magnets	aimants télescopiques
telescopic mirrors	miroirs télescopiques
tin snips	cisailles de ferblantier
torches (butane, propane, oxy-acetylene)	chalumeaux (au butane, au propane et oxyacétyléniques)
tri-tap tools	outils de taraudage triples
trouble lights	lampes baladeuses
vice grip pliers	pincés-étaux
water pump pliers (tongue-and-groove pliers)	pincés multiprises (pincés de plombier)
wire strippers	pincés à dénuder les fils
wood saws	scies à bois
wrenches (metric/imperial)	clés (métriques et impériales)

### **Portable Power Tools / Outils mécaniques portatifs**

band saws	scies à ruban
cable tuggers	tire-câbles
circular saws	scies circulaires
crimping tools (hydraulic/electric)	outils à sertir (hydrauliques et électriques)
cut-off saws	tronçonneuses
drills	perceuses
grinders	rectifieuses
hammer drills	marteaux perforateurs

heat guns  
hydraulic benders  
hydraulic crimpers  
hydraulic knock-out punches  
impact guns  
jig saws  
magnetic base drill presses  
pipe threading machines  
power pipe benders  
PVC conduit heaters  
reciprocating saws  
soldering equipment

pistolets à air chaud  
plieuses de tuyaux hydrauliques  
sertisseurs hydrauliques  
emporte-pièces hydrauliques  
clés à chocs  
scies sauteuses  
perceuses à colonne à base magnétique  
machines à fileter les tuyaux  
plieuses de tuyaux mécaniques  
appareils de chauffage de tuyaux en PVC  
scies alternatives  
machines de soudage

### **Powder-Actuated Tools / Outils à charge explosive**

exothermic welding equipment  
powder-actuated fastening tools

machines de soudage exothermique  
fixateurs à charge explosive

### **Stationary Power Tools / Outils mécaniques fixes**

band saws  
bearing heaters  
belt sanders  
bench grinders  
buffers  
chop saws  
drill presses  
hydraulic power units  
hydraulic presses  
parts washers  
portable grinders  
sand blasters  
threading machines  
under cutting machines

scies à ruban  
réchauffeurs de roulements  
ponceuses à courroie  
meuleuses d'établi  
meules de finition  
scies à onglets  
perceuses à colonne  
blocs d'alimentation hydrauliques  
presses hydrauliques  
machines à laver les pièces  
meuleuses portatives  
décapeuses par jet de sable  
fileteuses  
machines à entailler

### **Communication and Fibre Optic Tools / Outils pour câbles à fibres optiques et de télécommunications**

cleavers  
inspection scopes  
fusion splicers  
optical time-domain reflectometers (OTDR)  
optical power meters and light sources  
polishing pucks

couteaux à fibre optique  
caméras d'inspection  
fusionneuses  
réflectomètres optiques dans le domaine temporel  
wattmètres optiques et sources de lumière  
rondelles de polissage

swivels/fuses  
coaxial strippers and crimpers  
  
scissors  
voice/data crimp tools  
voice/data punch down tools  
time-domain reflectometers (TDR)

émerillons et fusibles  
outils à dénuder les câbles coaxiaux et sertisseuses de câbles coaxiaux  
  
ciseaux  
outils à sertir les câbles de transmission voix-données  
enrouleurs de câbles de transmission voix-données  
réflectomètres dans le domaine temporel

## **Electrical Test and Diagnostic Equipment / Appareils électriques de diagnostic et de vérification**

chart recorders  
circuit tracers  
clamp-on ammeters  
conductivity testers  
contact resistance meters  
frequency meters  
Geiger counters  
ground fault finders  
hipot testers  
instrumentation loop calibrators  
insulation resistance testers  
(megohmmeters/meggers)  
laptop computers and software  
light meters (light intensity)  
multimeters  
network analyzers  
non-contact voltage testers  
oscilloscopes  
panel meter calibrators  
phase sequence testers  
potential testers  
pressure calibration pumps  
signal generators  
sound level meters  
temperature guns  
thermal graphic cameras  
thermal graphic equipment  
timers  
voltage testers  
Wheatstone bridges

enregistreurs graphiques  
dépisteurs de circuits  
pinces ampèremétriques  
vérificateurs de conductivité  
mesureurs de la résistance de contact  
fréquencemètres  
compteurs Geiger  
détecteurs de fuites à la terre  
vérificateurs de rigidité diélectrique  
étalonneurs de boucles pour les instruments  
vérificateurs de résistance d'isolement (mégohmmètres)  
  
ordinateurs portables et logiciels  
luxmètres (lampes témoins)  
multimètres  
analyseurs de réseaux  
vérificateurs de tension sans contact  
oscilloscopes  
étalonneurs de panneau de mesure  
vérificateurs d'ordre des phases  
vérificateurs de potentiel  
pompes d'étalonnage de la pression  
générateurs de signaux  
décibelmètres  
thermomètres infrarouges  
caméras thermiques  
appareils thermiques  
minuteriers  
vérificateurs de tension  
ponts de Wheatstone

## **Mechanical Measuring Instruments and Devices / Appareils et dispositifs de mesure mécanique**

dial indicators	indicateurs à cadran
distance measuring wheels	roues de mesure de distance
feeler gauges (metric/imperial)	jauges d'épaisseur
hydrometers	hydromètres
micrometers	micromètres
pressure gauges	manomètres
protractors	rapporteurs d'angle
shaft alignment tools (dial and laser)	outils d'alignement d'arbres (à cadran et à laser)
tachometers	tachymètres
torque wrenches	clés dynamométriques
vernier calipers	pièdes à coulisse à vernier
vibration sensors (accelerometer, velocity, proximity)	capteurs de vibrations (accéléromètres, capteurs de vitesse, capteurs de proximité)

## **Rigging, Tugging, Hoisting, Lifting Material / Matériel de gréage, de tirage, de hissage et de levage**

articulated boom lifts	élévateurs à flèche articulée
beam clamps	attaches de poutre
block and tackle	palans à moufles
cable pullers (hand or electric powered)	tire-câbles (manuels ou électriques)
cable pulling grips (wire mesh grips)	tire-câbles en treillis métallique
chain fall/come-along	palans à chaîne et palans manuels à levier
hoists	treuils
jack stands	supports de sécurité
lifting eyes	anneaux de levage
platform lifts	plateformes élévatrices
pulleys (hook sheaves)	poulies (à crochet)
ropes	cordes
scissor lifts	plateformes élévatrices à ciseaux
shackles	manilles
slings (nylon and wire)	élingues
strain relief	réducteurs de tension
tray rollers	rouleaux pour chemin de câbles
tow motors/fork lifts	chariots tracteurs et chariots élévateurs à fourche

## **Scaffolding and Access Equipment / Échafaudages et appareils et dispositifs d'accès**

aerial work platforms (AWPs)	nacelles élévatrices
extension ladders	échelles à coulisse

man baskets  
platform lifts  
portable stairs  
scaffolds  
scissor lift  
step ladders

nacelles  
plateformes élévatrices  
marchepieds  
échafaudages  
plateformes élévatrices à ciseaux  
escabeaux

## **Personal Protective Equipment and Safety Equipment / Équipement de protection individuelle et équipement de sécurité**

air packs  
anchor slings (cable and nylon)  
arc flash PPE's

breaker locks (multi-lock, lock box, lock tag)

carabiners  
dust masks  
ear protectors (muffs and plugs)  
emergency eyewash equipment

face shields  
fall arrest equipment  
fall restraint equipment

fire extinguishers  
fire retardant clothing  
first aid equipment  
fume and toxic gas detectors  
grounding sticks

hard hats  
harnesses (full body)  
high visibility vests

high-voltage gloves (insulated)  
high-voltage test equipment  
hot gloves

hot pads  
hot sticks  
knee pads

lanyards (energy absorbing and twin leg)  
low-voltage gloves (insulated)  
protective aprons

protective gloves/gauntlets  
respirators (full-face and half-mask)  
rope grabs

appareils respiratoires Air-Pak  
élingues d'ancrage (à câble et en nylon)  
équipement de protection individuelle contre les arcs électriques  
dispositifs de cadenassage de disjoncteur (multipolaires, boîtiers de sécurité et étiquettes cadenas)

mousquetons  
masques antipoussières  
protège-oreilles (bouche-oreilles et casques antibruits)

douches oculaires d'urgence  
écrans faciaux  
dispositifs antichutes

dispositifs de retenue en cas de chute  
extincteurs  
vêtements ignifugés

trousses de premiers soins  
détecteurs de vapeurs et de gaz toxiques  
perches de mise à la terre

casques de protection  
harnais (complets)  
vestes réfléchissantes

gants de protection contre la haute tension (isolés)  
vérificateurs de haute tension  
gants isolants

tapis isolants  
perches isolantes  
protecteurs de genoux

longes de sécurité (amortisseuses et doubles)  
gants de protection contre la basse tension (isolés)  
tabliers de protection

gants et gantelets de protection  
respirateurs (masques complets et demi-masques)  
coulisseaux de sécurité



Self-Contained Breathing Apparatus (SCBA)	appareils de protection respiratoire autonomes
safety footwear	chaussures de sécurité
safety glasses/goggles	lunettes de sécurité et lunettes à coque
self-retracting lifelines	câbles de sécurité autorétractables
signage	panneaux d'avertissement
temporary protective ground equipment	conducteurs de mise à la terre de protection temporaire
welding gloves	gants de soudeur
welding helmets/masks	casques et masques de soudeur

# APPENDIX C

## GLOSSARY / GLOSSAIRE

<b>arc flash</b>	extremely high temperature electrical discharge produced by an electrical fault in the air that occurs on live equipment resulting from a low impedance connection to ground or another voltage phase in an electrical system. The intensity of the discharge is dependent on the size of the energy source and the orientation and size of the conductors	<b>arc électrique</b>	décharge électrique à très haute température causée par un défaut d'origine électrique dans l'air qui se produit sur un appareil sous tension en raison d'une connexion à faible impédance reliant la terre ou un autre conducteur de phase dans un réseau électrique. L'intensité de la décharge dépend de la puissance de la source d'énergie et du sens et de la grosseur des conducteurs.
<b>bonding</b>	low impedance path obtained by permanently joining all non-current-carrying metal parts to assure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it	<b>liaison par continuité des masses</b>	liaison de faible impédance réalisée en reliant de façon permanente toutes les pièces métalliques non porteuses de courant dans le but d'assurer une continuité électrique; cette liaison doit pouvoir acheminer, en toute sécurité, tout courant susceptible de la parcourir.
<b>cable</b>	a complete manufactured assembly of one or more insulated conductors, optical fibres, or both which may have fillers, strength members, and insulating and protective material, and may also have a continuous overall covering providing a degree of electrical, mechanical and environmental protection to the assembly	<b>câble</b>	assemblage constitué d'au moins un conducteur isolé ou de fibres optiques, ou des deux, qui pourraient comprendre du remplissage, des éléments de renforcement et des matériaux isolants et de protection, et qui pourrait comprendre aussi une enveloppe continue assurant une certaine protection électrique, mécanique et environnementale de l'ensemble.
<b>cathodic protection</b>	protection technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell	<b>protection cathodique</b>	technique de protection utilisée pour empêcher la corrosion d'une surface métallique en rendant cette surface la cathode d'une cellule électrochimique.
<b>commissioning</b>	initial startup of new equipment systematically to OEM specifications	<b>mise en service</b>	démarrage initial d'un nouvel appareil de façon absolument conforme aux spécifications du fabricant d'équipement d'origine
<b>dip switches</b>	a group of miniature switches	<b>interrupteurs DIP</b>	ensemble d'interrupteurs miniatures

<b>extra-low-voltage</b>	any voltage up to and including 30 V AC or 42.4 V DC as per CEC	<b>très basse tension</b>	selon le CCE, tension qui ne dépasse pas 30 V CA ou 42,2 V CC.
<b>grounding</b>	permanent and continuous conductive path to the earth with sufficient ampacity to carry any fault current liable to be imposed on it, and of a sufficiently low impedance to limit the voltage rise above ground and to facilitate the operation of the protective devices in the circuit	<b>mise à la terre</b>	liaison permanente et ininterrompue à la terre de courant admissible suffisant pour acheminer tout courant de défaut susceptible de la parcourir, et d'impédance suffisamment faible pour limiter la hausse de tension par rapport à la terre, de façon que les dispositifs de protection du circuit fonctionnent librement.
<b>high-voltage</b>	any voltage exceeding 1 000 V AC or 1 060 V DC as per CEC	<b>haute tension</b>	selon le CCE, tension supérieure à 1 000 V CA ou 1 060 V CC.
<b>low-voltage</b>	any voltage exceeding 30 V AC but not exceeding 1 000 V AC or exceeding 42.4 V DC but not exceeding 1 060 V DC as per CEC	<b>basse tension</b>	selon le CCE, tension supérieure à 30 V CA sans excéder 1 000 V CA ou supérieure à 42,4 V CC sans excéder 1 060 V CC.
<b>raceway</b>	any channel designed for holding wires, cables, or busbars, and, unless otherwise qualified by rules of the CEC, the term includes conduit (rigid, flexible, metal, non-metallic), electrical, metallic and nonmetallic (EMT and ENT) underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters	<b>canalisation</b>	tout canal conçu pour contenir des fils, des câbles ou des barres omnibus. À moins d'être qualifié autrement dans les articles du CCE, ce terme comprend les conduits (rigides et flexibles, métalliques et non métalliques), les tubes électriques métalliques et non métalliques, les canalisations de plancher, les planchers cellulaires, les moulures, les goulottes guide-fils, les chemins de câbles, les barres blindées et les caniveaux auxiliaires.
<b>unit equipment</b>	a piece of equipment with its own storage battery, charging means, transfer switch, lamps or output terminals, test switch and indicators	<b>luminaire autonome</b>	appareil muni d'un accumulateur, d'un chargeur, d'un commutateur de transfert, de lampes ou de bornes de sortie, d'un interrupteur de test et d'indicateurs.