PROGRAM PROGRAMME
EXCELLENCE
RED SEAL · SCEAU ROUGE

Red Seal Occupational Standard

Industrial Electrician

2016

INTERPROVINCIAL STANDARD
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Canada

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RED SEAL OCCUPATIONAL STANDARD

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 Regulated Occupations Directorate
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Gatineau, Quebec K1A 0J9
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Acknowledgement is extended by ESDC and the CCDA to National Electrical Trade Council (NETCO), who provided advice on the development of the standard.

Special thanks are offered to the following representatives who contributed greatly to the original draft of the standard and provided expert advice throughout its development:

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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. The host jurisdiction of Ontario also participated in the development of this standard.

STRUCTURE OF THE OCCUPATIONAL STANDARD

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

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

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

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

Pie Chart: a graph which depicts the national percentages of exam questions assigned to the major work activities

Task Matrix and Examination Weightings: a chart which outlines graphically the major work activities, tasks and sub-tasks of this standard and their respective exam weightings

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

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

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

Psychomotor Taxonomy: A classification to describe the type of psychomotor (physical) process that would be most used in completing the sub-task

Cognitive Taxonomy: A classification to describe the type of cognitive (thinking) process that would be most used in completing the sub-task

Assessment Methods: Potential assessment methods that have been identified by industry experts that could be used to assess a candidate's competence in the sub-task

Essential Skills: The most relevant essential skills for this sub-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 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: a non-exhaustive list of tools and equipment used in this trade

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

A complete version of the occupational standard, which provides additional detail for the trade activities, skills and knowledge can be found at www.red-seal.ca

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 whose occupational title has been identified by some provinces and territories of Canada under the following names:

	NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
Electrician (Non-Construction)					■								
Industrial Electrician	■	■	■	■		■	■			■	■	■	

Industrial electricians install, maintain, test, troubleshoot, service and repair industrial electrical equipment and associated electrical 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 electrical contractors and maintenance departments of plants, mines, manufacturing facilities, government, and other industrial establishments.

Industrial electricians must read and interpret 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 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 extreme 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.

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.

A series of CCDA-endorsed tools have been developed to support apprentices in their training and to be better prepared for a career in the trades. The tools can be used independently or with the assistance of a tradesperson, trainer, employer, teacher or mentor to:

- understand how essential skills are used in the trades;
- learn about individual essential skills strengths and areas for improvement; and
- improve essential skills and increase success in an apprenticeship program.

The tools are available online or for order at: https://www.canada.ca/en/employment-social-development/programs/essential-skills/tools.html

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 most important essential skills for each sub-task have also been identified. The following are summaries of the requirements in each of the essential skills, taken from the essential skills profile. A link to the complete essential skills profile can be found at www.red-seal.ca

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.

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.

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.

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.

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.

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.

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.

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, co-ordinating their work with the work of others, but for large jobs they work with a partner or crew.

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.

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. Control and monitoring of electrical equipment is starting to migrate to both wired and wireless technology utilizing the platform of 'Internet of things' (IoT).

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) and distributed control systems (DCSs) facilitate the monitoring and control of industrial processes and building 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 process 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 are becoming more common in industry causing a change in focus and 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) 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 such as light emitting diode (LED) lighting, automated lighting control and variable speed drives. Industrial electricians need to be aware of governmental programs and 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 new technology.

Safety

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 has increased in process control, environmental control and building control systems. There is now an increased emphasis on accountability for safety in the workplace.

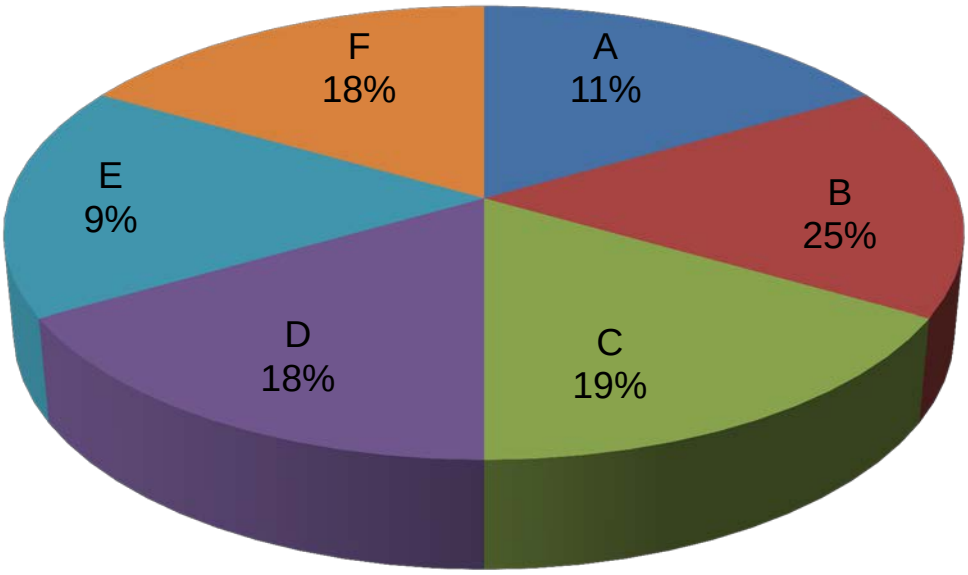
INDUSTRY EXPECTED PERFORMANCE

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 the manufacturer, company and client specifications, the Canadian Electrical Code (CEC) and Authority having Jurisdiction (AHJ) 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 keep 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	11%
MWA B	Installs and Maintains Generating, Distribution and Service Systems	25%
MWA C	Installs and Maintains Wiring Systems	19%
MWA D	Installs and Maintains Rotating and Non-Rotating Equipment and Control Systems	18%
MWA E	Installs and Maintains Signalling and Communication Systems	9%
MWA F	Installs and Maintains Process Control Systems	18%

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

A - PERFORMS COMMON OCCUPATIONAL SKILLS — 11%

Task A-1 **Performs safety-related functions** **25%**	**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		
Task A-2 **Uses tools and equipment** **20%**	**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**
Task A-3 **Organizes work** **16%**	**A-3.01 Interprets plans, drawings and specifications**	**A-3.02 Identifies hazardous locations**	**3.03 Organizes materials and supplies**
	A-3.04 Plans project tasks and procedures	**A-3.05 Prepares worksite**	**A-3.06 Finalizes required documentation**
Task A-4 **Fabricates and installs support components** **15%**	**A-4.01 Fabricates support structures**	**A-4.02 Installs brackets, hangers and fasteners**	**A-4.03 Installs seismic restraint systems**
Task A-5 **Commissions and decommissions electrical systems** **18%**	**A-5.01 Commissions systems**	**A-5.02 Performs shutdown and startup procedures**	**A-5.03 Decommissions systems**
Task A-6 **Uses communication and mentoring techniques** **6%**	**A-6.01 Uses communication techniques**	**A-6.02 Uses mentoring techniques**	

B - INSTALLS AND MAINTAINS GENERATING, DISTRIBUTION AND SERVICE SYSTEMS

25%

Task B-7 **Installs and maintains consumer/supply services and metering equipment** **13%**	**B-7.01 Installs single-phase consumer/supply services and metering equipment**	**B-7.02 Maintains single-phase consumer/supply services and metering equipment**	**B-7.03 Installs three-phase consumer/supply services and metering equipment**
	B-7.04 Maintains three-phase consumer/supply services and metering equipment		
Task B-8 **Installs and maintains protection devices** **14%**	**B-8.01 Installs overcurrent protection devices**	**B-8.02 Maintains overcurrent protection devices**	**B-8.03 Installs ground fault, arc fault and surge protection devices**
	B-8.04 Maintains ground fault, arc fault and surge protection devices	**B-8.05 Installs under and over voltage protection devices**	**B-8.06 Maintains under and over voltage protection devices**
Task B-9 **Installs and maintains low voltage distribution systems** **11%**	**B-9.01 Installs low voltage distribution equipment**	**B-9.02 Maintains low voltage distribution equipment**	
Task B-10 **Installs and maintains power conditioning systems** **10%**	**B-10.01 Installs power conditioning systems**	**B-10.02 Maintains power conditioning systems**	
Task B-11 **Installs and maintains bonding, grounding and ground fault detection systems** **14%**	**B-11.01 Installs grounding systems**	**B-11.02 Maintains grounding systems**	**B-11.03 Installs bonding systems**
	B-11.04 Maintains bonding systems	**B-11.05 Installs ground fault detection systems**	**B-11.06 Maintains ground fault detection systems**

Task B-12 **Installs and maintains power generating systems** **9%**	**B-12.01 Installs alternating current (AC) generating systems**	**B-12.02 Maintains AC generating systems**	**B-12.03 Installs direct current (DC) generating systems**
	B-12.04 Maintains DC generating systems		
Task B-13 **Installs and maintains renewable energy generating and storage systems** **7%**	**B-13.01 Installs renewable energy generating and storage systems**	**B-13.02 Maintains renewable energy generating and storage systems**	
Task B-14 **Installs and maintains high voltage systems** **9%**	**B-14.01 Installs high voltage systems**	**B-14.02 Maintains high voltage systems**	
Task B-15 **Installs and maintains transformers** **13%**	**B-15.01 Installs extra-low voltage transformers**	**B-15.02 Maintains extra-low voltage transformers**	**B-15.03 Installs low voltage single-phase transformers**
	B-15.04 Maintains low voltage single-phase transformers	**B-15.05 Installs low voltage three-phase transformers**	**B-15.06 Maintains low voltage three-phase transformers**
	B-15.07 Installs high voltage transformers	**B-15.08 Maintains high voltage transformers**	

C - INSTALLS AND MAINTAINS WIRING SYSTEMS — 19%

Task C-16 **Installs and maintains raceways, cables, conductors and enclosures** **31%**	**C-16.01 Installs conductors and cables**	**C-16.02 Maintains conductors and cables**	**C-16.03 Installs conduit, tubing and fittings**
	C-16.04 Installs raceways	**C-16.05 Installs boxes and enclosures**	**C-16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures**
Task C-17 **Installs and maintains branch circuitry and devices** **26%**	**C-17.01 Installs luminaires**	**C-17.02 Maintains luminaires**	**C-17.03 Installs wiring devices**
	C-17.04 Maintains wiring devices		
Task C-18 **Installs and maintains heating, ventilation and air-conditioning (HVAC) electrical components** **13%**	**C-18.01 Connects power to HVAC systems and associated equipment**	**C-18.02 Installs HVAC controls**	**C-18.03 Maintains HVAC electrical components**
Task C-19 **Installs and maintains electric heating systems and controls** **14%**	**C-19.01 Installs electric heating systems and controls**	**C-19.02 Maintains electric heating systems and controls**	
Task C-20 **Installs and maintains exit and emergency lighting systems** **9%**	**C-20.01 Installs exit and emergency lighting systems**	**C-20.02 Maintains exit and emergency lighting systems**	
Task C-21 **Installs and maintains cathodic protection systems** **7%**	**C-21.01 Installs cathodic protection systems**	**C-21.02 Maintains cathodic protection systems**	

D - INSTALLS AND MAINTAINS ROTATING AND NON-ROTATING EQUIPMENT AND CONTROL SYSTEMS

18%

Task D-22 **Installs and maintains motor starters and control devices** **32%**	**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		
Task D-23 **Installs and maintains drives** **26%**	**D-23.01 Installs AC drives**	**D-23.02 Maintains AC drives**	**D-23.03 Installs DC drives**
	D-23.04 Maintains DC drives		
Task D-24 **Installs and maintains non-rotating equipment and associated controls** **15%**	**D-24.01 Installs non-rotating equipment and associated controls**	**D-24.02 Maintains non-rotating equipment and associated controls**	
Task D-25 **Installs and maintains motors** **27%**	**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 DC motors**	**D-25.06 Maintains DC motors**

E - INSTALLS AND MAINTAINS SIGNALLING AND COMMUNICATION SYSTEMS

9%

Task E-26 **Installs and maintains signalling systems** **37%**	**E-26.01 Installs fire alarm systems**	**E-26.02 Maintains fire alarm systems**	**E-26.03 Installs security and surveillance systems**
	E-26.04 Maintains security and surveillance systems		
Task E-27 **Installs and maintains communication systems** **32%**	**E-27.01 Installs communication systems**	**E-27.02 Maintains communication systems**	
Task E-28 **Installs and maintains building automation systems** **31%**	**E-28.01 Installs building automation systems**	**E-28.02 Maintains building automation systems**	

F - INSTALLS AND MAINTAINS PROCESS CONTROL SYSTEMS — 18%

Task F-29 **Installs and maintains input/output (I/O) devices** **41%**	**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		
Task F-30 **Installs, programs and maintains automated control systems** **37%**	**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		
Task F-31 **Installs and maintains pneumatic and hydraulic control systems** **22%**	**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		

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, company, client 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. Industrial electricians must ensure that equipment follows CEC and AHJ when installed in environmentally adverse and hazardous locations. Industrial electricians need to be aware and follow proper disposal methods for environmentally hazardous materials.

A-1.01 Maintains safe work environment

Essential Skills Thinking, Document Use, Oral Communication

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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 ***hazards***	***hazards*** are identified, reported and mitigated
A-1.01.03P	set up ***barriers*** and ***signage*** to explain ***hazards***	***hazards*** are well marked by ***barriers*** and ***signage***
A-1.01.04P	store materials and equipment	materials and equipment are stored in designated areas, according to WHMIS, company and client policies and practices, site-specific practices and AHJ
A-1.01.05P	identify and respect physical limitations of self and others	identify physical limitations and work within them
A-1.01.06P	set up and identify locations containing ***safety components***	locations are identified with signage and on job site map
A-1.01.07P	enforce safe work practices	safe work practices are followed

A-1.01.08P	identify materials hazardous to personnel	***hazardous materials*** are identified by reading equipment labels and product documentation
A-1.01.09P	contain ***hazardous materials***	***hazardous materials*** are contained and disposed of according to jurisdictional regulations and company policy

RANGE OF VARIABLES

hazards include: arc flashes/blasts, liquid spills (flammable, corrosive, toxic), electric shocks, designated substance (asbestos, mercury, lead, silica), combustible dust, radiation, open holes, confined space, fire, tripping hazards, overhead work, working at heights, hazardous locations as defined by the CEC

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

safety components include: first aid kits, fire extinguishers, safety data sheets (SDS), eye wash stations, automated external defibrillator (AED)

hazardous materials include: PCB, mercury, CFC, asbestos

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-1.01.01L	demonstrate knowledge of safe work practices	identify ***hazards*** and describe safe work practices
		describe the procedures used in ***emergency situations***
A-1.01.02L	demonstrate knowledge of regulatory requirements pertaining to ***hazards*** and ***emergency situations***	identify and interpret the regulatory requirements pertaining to ***hazards*** and ***emergency situations***
A-1.01.03L	demonstrate knowledge of containment methods	describe containment methods for ***hazardous materials***

RANGE OF VARIABLES

hazards include: arc flashes/blasts, liquid spills (flammable, corrosive, toxic), electric shocks, designated substance (asbestos, mercury, lead, silica), combustible dust, radiation, open holes, confined space, fire, tripping hazards, overhead work, working at heights, hazardous locations as defined by the CEC

emergency situations include: explosions, fire, hazardous product release

hazardous materials include: PCB, mercury, CFC, asbestos

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

Essential Skills Thinking, Document Use, Continuous Learning

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-1.02.01P	identify ***site hazards*** and regulations requiring the use of ***PPE*** and ***safety equipment***	***site hazards*** are determined by site visits and by doing a pre-job analysis
A-1.02.02P	select ***PPE*** and ***safety equipment***	***PPE*** and ***safety equipment*** are selected to match tasks and hazardous situations
A-1.02.03P	recognize worn, damaged or defective ***PPE*** and ***safety equipment***	***PPE*** and ***safety equipment*** are inspected prior to use and not used when damaged or faulty, and tagged as such
A-1.02.04P	ensure fit of ***PPE*** for the application	***PPE*** are adjusted to provide maximum protection for the individual
A-1.02.05P	apply ***safety regulations and standards***	***safety regulations and standards*** are followed according to company, client, site and AHJ requirements
A-1.02.06P	organize, clean and store ***PPE*** and ***safety equipment***	organizing, cleaning and storage procedures are done according to company procedures and manufacturers' specifications
A-1.02.07P	recognize limitation of use of ***PPE*** and ***safety equipment***	***PPE*** and ***safety equipment*** are not used for other than their intended purposes according to manufacturers' limitation specifications

RANGE OF VARIABLES

site hazards include: working at heights, confined space, open excavation, live equipment, extreme weather conditions, hazardous locations as defined by the CEC, oxygen deficient atmospheres

PPE includes: shock hazard PPE, arc flash hazard PPE, hard hats, safety glasses, safety footwear, gloves, hearing protection

safety equipment includes: fall protection (fall arrest and fall restraint), confined space equipment, respiratory protection, tag-out and lock-out equipment, fire extinguishers, first aid equipment, eye wash stations, signage, fume and toxic gas detectors

safety regulations and standards include: WHMIS, AHJ, CSA Z460, Z462 and Z463, company and client safety policy, general/prime contractor policies

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-1.02.01L	demonstrate knowledge of ***PPE*** and ***safety equipment***, their ***applications***, maintenance, storage and procedures for use	identify types of ***PPE*** and ***safety equipment***
		describe ***applications*** and limitations of ***PPE*** and ***safety equipment***
		describe the procedures used to care for, inspect, maintain and store ***PPE*** and ***safety equipment***
A-1.02.02L	demonstrate knowledge of regulatory requirements pertaining to ***PPE*** and ***safety equipment***	identify and interpret the regulatory requirements and responsibilities

RANGE OF VARIABLES

PPE includes: shock hazard PPE, arc flash hazard PPE, hard hats, safety glasses, safety footwear, gloves, hearing protection

safety equipment includes: fall protection (fall arrest and fall restraint), confined space equipment, respiratory protection, tag-out and lock-out equipment, fire extinguishers, first aid equipment, eye wash stations, signage, fume and toxic gas detectors

applications include: hazardous locations, height, confined space

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

Essential Skills Thinking, Oral Communication, Working with Others

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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 company policy and sequence of events
A-1.03.02P	identify circuit for lock-out and tag-out, and recognize other equipment that may present a hazard	circuit isolation point(s) and voltage are identified by referring 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 ***approved device***	PPE and ***approved device*** is selected to match the equipment and to ensure lock-out and tag-out

A-1.03.04P	identify potential energy source	potential energy source is identified to de-energize and lock-out equipment, and isolate circuit
A-1.03.05P	test system for zero potential	system is tested for absence of voltage by using ***voltage-rated equipment***
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

RANGE OF VARIABLES

approved devices include: breaker lock, multi-lock, lock box, tag and arc flash protection equipment
voltage-rated equipment includes: voltmeters, ground straps, high voltage testers

	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 and legislation
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 procedures for voltage testing	describe how to determine if the testing equipment to be used is matched to the voltage and energy rating

A-1.04 Identifies environmental conditions

Essential Skills	Reading, Document Use, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-1.04.01P	recognize ***environmental conditions*** of site location	***environmental conditions*** of site location are recognized through sensory inspection, and according to plans and company and client specifications
A-1.04.02P	select equipment	equipment is selected according to ***environmental conditions***, manufacturers' specifications and codes
A-1.04.03P	select cabling and raceways	cabling and raceways are selected according to ***environmental conditions***, manufacturers' specifications and codes

RANGE OF VARIABLES

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

KNOWLEDGE

	Learning Outcomes	Learning Objectives
A-1.04.01L	demonstrate knowledge of ***environmental conditions*** and installation procedures	identify types of ***environmental conditions*** and describe safe work procedures
		identify equipment designed for installation and operation in areas according to environmental conditions
		identify and describe wiring procedures and methods for areas according to environmental conditions

RANGE OF VARIABLES

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

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

Essential Skills Thinking, Document Use, Continuous Learning

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

SKILLS

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

RANGE OF VARIABLES

tools and equipment include: standard hand tools, power tools and equipment, specialty tools and equipment, measuring equipment

components include: chucks, bits, blades, cords, attachment plugs

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-2.01.01L	demonstrate knowledge of ***tools and equipment***, their applications and procedures for use	identify types of ***tools and equipment*** and describe their applications and procedures for use
		describe operating and maintenance procedures of ***tools and equipment*** according to manufacturers' requirements
A-2.01.02L	demonstrate knowledge of inspection procedures	describe the procedures used to inspect ***tools and equipment***
A-2.01.03L	demonstrate knowledge of limitations and ratings of electrical measuring equipment	describe limitations of measuring equipment and identify measuring equipment for task at hand
		identify the categories of electrical measuring equipment
A-2.01.04L	demonstrate knowledge of certification requirements to operate powder-actuated tools	describe certification requirements to use powder-actuated tools

RANGE OF VARIABLES

tools and equipment include: standard hand tools, power tools and equipment, specialty tools and equipment, measuring equipment

A-2.02 Uses access equipment

Essential Skills Thinking, Document Use, Reading

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-2.02.01P	identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified according to job site
A-2.02.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and ***potential hazards***
A-2.02.03P	select ***access equipment***	***access equipment*** is selected according to their limitation 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	visually and mechanically inspect for worn, damaged and defective ***access equipment***	***access equipment*** is inspected for ***damage***
A-2.02.06P	report, tag and decommission ***access equipment***	unsafe, worn, damaged and defective ***access equipment*** is tagged and removed from service
A-2.02.07P	organize and store ***access equipment***	***access equipment*** is stored according to manufacturers' specifications and job site requirements
A-2.02.08P	work from approved and certified ***access equipment***	***access equipment*** is certified and approved for job task and the operator is certified in the equipment use according to AHJ

RANGE OF VARIABLES

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

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

damage includes: broken ladder, leaking oil, out-of-line safety chains and gates

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-2.02.01L	demonstrate knowledge of ***access equipment***, their applications, limitations and procedures for use	identify types of ***access equipment*** and describe their characteristics and applications
		identify hazards and describe safe work practices pertaining to ***access equipment***
		describe the procedures used to erect and dismantle ladders and scaffolding, according to AHJ
		describe the procedures used to inspect, maintain and store ***access equipment***
		identify certification for use of ***access equipment***
A-2.02.02L	demonstrate knowledge of ***regulatory requirements*** pertaining to ***access equipment***	identify and interpret the regulatory requirements and responsibilities pertaining to ***access equipment***

RANGE OF VARIABLES

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

regulatory requirements include: inspection documentation, training and certification

A-2.03 Uses rigging, hoisting and lifting equipment

Essential Skills	Thinking, Working with Others, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-2.03.01P	identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified according to job site
A-2.03.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and ***potential hazards***
A-2.03.03P	select rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is selected according to their limitation and task at hand
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	ensure capacity of rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment loading capacity meets engineering and AHJ requirements
A-2.03.07P	visually and mechanically inspect for worn, damaged and defective rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is inspected for ***damages***
A-2.03.08P	report, tag and decommission unsafe, damaged and defective rigging, hoisting and lifting equipment	damaged and defective rigging, hoisting and lifting equipment is tagged and removed from service
A-2.03.09P	secure load for application	load is secured according to engineer and manufacturers' specifications, AHJ requirements and company policy
A-2.03.10P	clean, lubricate and store rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is cleaned, lubricated and stored according to company procedures and manufacturers' specifications
A-2.03.11P	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 worksites, confined spaces, 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 and procedures for use
		identify types of hoisting and lifting equipment and accessories and describe their applications and procedures for use
		identify ***potential hazards*** and describe safe work practices pertaining to hoisting, lifting and rigging
		describe the procedures used to inspect, maintain and store hoisting, lifting and rigging equipment
A-2.03.02L	demonstrate knowledge of ***regulatory requirements*** pertaining to hoisting, lifting and rigging equipment	identify and interpret codes and regulations pertaining to hoisting, lifting and rigging
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 the procedures used to tie them
		describe the ***considerations*** when rigging material/equipment for lifting
		identify and describe ***procedures used to communicate*** during hoisting, lifting and rigging operations

RANGE OF VARIABLES

potential hazards include: overhead hazards, overhead power hazards, dropped loads, damaged rigging hardware, congested worksites, confined spaces, 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 used to communicate include: hand signals, electronic communications, audible/visual

TASK A-3 Organizes work

TASK DESCRIPTOR

Industrial electricians organize projects 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 they must plan their tasks, identify environmental conditions, identify hazardous locations, prepare the worksite 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

Essential Skills Document Use, Reading, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-3.01.01P	identify symbols found on drawings and specifications	symbols 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 making a measurement using 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, ***drawings, schematics and specifications*** are current	plans, ***drawings, schematics and specifications*** are compared with the existing installation

RANGE OF VARIABLES

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

KNOWLEDGE

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

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

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

A-3.02 Identifies hazardous locations

Essential Skills Document Use, Thinking, Reading

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-3.02.01P	identify ***hazardous locations***	***hazardous locations*** are identified according to area classification drawings and AHJ
A-3.02.02P	identify wiring methods used in ***hazardous locations***	wiring methods are selected according to AHJ and CEC requirements
A-3.02.03P	identify equipment used in ***hazardous locations***	equipment is identified by reading equipment labels and product documentation
A-3.02.04P	identify locations for where sealing is required	seals are located according to AHJ and CEC requirements

RANGE OF VARIABLES

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-3.02.01L	demonstrate knowledge of ***hazardous locations***	identify types of ***hazardous locations*** and describe safe work procedures
		identify types of potentially hazardous materials present and the procedures to designate an area to be a ***hazardous location***
		identify equipment and fittings designed for installation and operation in ***hazardous locations***
A-3.02.02L	demonstrate knowledge of ***hazardous locations*** wiring methods	identify and describe wiring methods in ***hazardous locations***

RANGE OF VARIABLES

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

A-3.03 Organizes materials and supplies

Essential Skills Document Use, Reading, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-3.03.01P	identify and select ***materials*** and ***supplies***	***materials*** and ***supplies*** are selected according to drawings, specifications, WHMIS requirements and CEC requirements
A-3.03.02P	locate, order and schedule delivery of ***materials*** and ***supplies***	***materials*** and ***supplies*** are ordered and delivered according to ***criteria***
A-3.03.03P	load, unload and store ***materials*** and ***supplies***	***materials*** and ***supplies*** are loaded, unloaded and stored according to ***factors***
A-3.03.04P	perform material take-off to identify required ***materials*** and ***supplies***	***materials*** and ***supplies*** are identified according to drawings and specifications
A-3.03.05P	coordinate receiving of ***materials*** and ***supplies*** to ensure delivery of shipment	***materials*** and ***supplies*** are received according to established schedule

A-3.03.06P	verify shipments of ***materials*** and ***supplies*** to ensure that quality and quantity match order	***materials*** and ***supplies*** are counted and compared to order and are inspected for shipping damage
A-3.03.07P	perform inventory control	inventory is counted and stored in secured area

RANGE OF VARIABLES

materials include: wires and cables, luminaires, panel boards, 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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-3.03.01L	demonstrate knowledge of the procedures used to plan and organize ***materials*** and ***supplies***	identify ***sources of information*** relevant to organize ***materials*** and ***supplies***
		describe the ***considerations*** to organize ***materials*** and ***supplies***

RANGE OF VARIABLES

materials include: wires and cables, luminaires, panel boards, 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, company, client and manufacturer requirements, SDS

considerations include: available space, schedule, storage location

A-3.04 Plans project tasks and procedures

Essential Skills	Thinking, Document Use, Working with Others

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-3.04.01P	visually inspect work environment to determine job requirements from ***documentation***	job requirements are determined by site visit and ***documentation***
A-3.04.02P	determine labour and equipment requirements	labour and equipment requirements are determined according to ***job specifications***
A-3.04.03P	establish and maintain schedules	schedules are maintained according to ***criteria***
A-3.04.04P	coordinate work with other trades	work is coordinated with other trades according to ***requirements***
A-3.04.05P	draw and sketch layouts	layouts are determined according to the installation task at hand

RANGE OF VARIABLES

documentation includes: site visit log, manufacturers' specifications, drawings (civil/site, architectural, mechanical, structural, shop, electrical, single line), sketches, logic diagram, company, client and manufacturer requirements

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

criteria include: 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 the procedures used to plan and organize job tasks	identify ***sources of information*** relevant to planning job tasks and procedures
		describe the ***considerations*** to plan and organize job tasks and procedures
		describe the function of project schedule tools

RANGE OF VARIABLES

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

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

A-3.05 Prepares worksite

Essential Skills Thinking, Document Use, Reading

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-3.05.01P	perform pre-job assessment	pre-job assessment is performed by site visit
A-3.05.02P	visually inspect to identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified by site visit
A-3.05.03P	participate in worksite safety meetings	worksite safety meeting addresses risks and dangers and how they will be controlled
A-3.05.04P	install barricades and signage to contain work zone	work zone is contained according to job requirements and AHJ
A-3.05.05P	create openings and penetrations in building elements and equipment	openings and penetrations are created according to job requirements and AHJ
A-3.05.06P	ensure sufficient lighting and ventilation of work area	work area is ventilated and level of lighting is according to AHJ
A-3.05.07P	ensure required materials and equipment are on site	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 and ***locates*** are completed and marked-out	***locates*** are identified and marked-out

RANGE OF VARIABLES

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

locates include: underground services and utilities, concealed building elements

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-3.05.01L	demonstrate knowledge of the procedures used to prepare worksite	identify ***sources of information*** relevant to prepare worksite
		identify ***potential hazards*** relevant to prepare worksite
		describe the ***considerations*** to prepare worksite
A-3.05.02L	demonstrate knowledge of the procedures used to locate ***elements***	identify types of surveying equipment used to locate ***elements*** in concrete walls and floors, slab on grade and direct buried
		describe the 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 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

Essential Skills Document Use, Writing, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-3.06.01P	document alterations by modifying plans, schematics and drawings to reflect changes and additions made to original application	plans, schematics and drawings are modified to reflect installation changes
A-3.06.02P	log data from various ***sources*** to assist with maintenance and replacement	paper and digital copies of setting and parameter files are saved to assist with maintenance

A-3.06.03P	compile maintenance manuals from installed equipment manufacturers' specifications	product data sheets for equipment are included in the maintenance manuals
A-3.06.04P	submit required final documentation, including as-built drawings, to company and client	as-built drawings and O&M manuals are submitted to company and client according to job specifications

RANGE OF VARIABLES

sources include: equipment parameters such as VFD, HMI, PLC, drawings, schematics, programs

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-3.06.01L	demonstrate knowledge of ***documentation***, its purpose, application and use	describe and identify types of ***documentation*** developed from tasks
		describe procedures for finalizing ***documentation***

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 a secondary support when required.

A-4.01 Fabricates support structures

Essential Skills Numeracy, Document Use, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-4.01.01P	evaluate equipment to determine support structure size, strength and weight	dimensions of support structure is determined according to equipment size and requirements
A-4.01.02P	draw sketch	sketch is drawn with dimensions and measurements of support structure and equipment
A-4.01.03P	determine ***material*** for support structure	***materials*** are selected according to job specifications and ***factors***
A-4.01.04P	select and use ***fasteners***	***fasteners*** are selected to meet job specifications and site conditions
A-4.01.05P	prepare ***material***	***materials*** are prepared by cutting and drilling holes to size according to sketch and by painting and coating for corrosion protection
A-4.01.06P	assemble material to create structure	structure is assembled according to sketch, and is straight and free of sharp protrusions

RANGE OF VARIABLES

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, insulators

	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 ***materials***, their characteristics and application
		identify ***fasteners***, their characteristics and application according to job specifications and site conditions
A-4.01.02L	demonstrate knowledge of procedures for fabricating support structures	describe procedures used to fabricate support structures

RANGE OF VARIABLES

materials include: wood, steel, aluminum

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

A-4.02 Installs brackets, hangers and fasteners

Essential Skills	Document Use, Thinking, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-4.02.01P	select ***brackets***, ***hangers*** and ***fasteners***	***brackets***, ***hangers*** and ***fasteners*** are selected according to job specifications and intended purposes
A-4.02.02P	determine installation location	installation location is determined to avoid ***obstructions***
A-4.02.03P	secure ***brackets*** and ***hangers*** to structure using ***fasteners***	***brackets*** and ***hangers*** are secured using ***fasteners,*** and are level, square, following building lines when possible, according to job specifications and intended purposes, company, client and manufacturer specifications and CEC requirements

RANGE OF VARIABLES

brackets include: 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 members, equipment

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-4.02.01L	demonstrate knowledge of ***brackets***, ***hangers*** and ***fasteners***, their applications, and their use	identify types of ***brackets***, ***hangers*** and ***fasteners***, their characteristics and application
		describe procedures for securing ***brackets***, ***hangers*** and ***fasteners*** to structure
		identify ***building materials***, their characteristics and application
A-4.02.02L	demonstrate knowledge of measurement and layout techniques	identify measurement and layout techniques to ensure ***brackets***, ***hangers*** and ***fasteners*** are positioned and mounted according to job specifications, company, client, manufacturer and CEC requirements

RANGE OF VARIABLES

brackets include: 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

Essential Skills	Document Use, Reading, Thinking

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
no	yes	yes	yes	NV	yes	no	ND	ND	yes	ND	NV	ND

SKILLS

	Performance Criteria	Evidence of Attainment
A-4.03.01P	select and fabricate ***seismic restraint systems***	***seismic restraint systems*** are selected and fabricated according to job specifications and jurisdictional regulations
A-4.03.02P	determine installation location	installation location is determined to avoid ***obstructions***
A-4.03.03P	position, mount and secure ***seismic restraint systems*** to structure	***seismic restraint systems*** are positioned, mounted and secured according to structure location, job specifications and jurisdictional regulations

RANGE OF VARIABLES

seismic restraint systems include: chains, cables, rods, wire rope, shock mounts
obstructions include: duct work, plumbing pipes, structural members, equipment

KNOWLEDGE

	Learning Outcomes	Learning Objectives
A-4.03.01L	demonstrate knowledge of ***seismic restraint systems,*** their applications and their use	identify types of ***seismic restraint systems***, their characteristics and limitations
		describe procedures for mounting and securing ***seismic restraint systems*** to structure
		identify materials to be installed

RANGE OF VARIABLES

seismic restraint systems include: chains, cables, rods, wire rope

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 equipment manufacturers 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

Essential Skills Thinking, Working with Others, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-5.01.01P	isolate ***potential*** from equipment	equipment is de-energized using lockout and tagging 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	verify busbar connections and torquing of bolts	busbars are torqued according to manufacturers' specifications
A-5.01.05P	collaborate with other trades involved in commissioning of system	identify other trades involved in commissioning of system and ensure they are informed
A-5.01.06P	visually inspect system for ***problems***	***problems*** are identified and corrected
A-5.01.07P	confirm ***system components*** are functional	***system components*** are operating to their intended purpose
A-5.01.08P	test system	system is tested according to manufacturers' and design specifications
A-5.01.09P	perform ***operational checks***	results of ***operational checks*** are documented

A-5.01.10P	adjust components to achieve desired operation	adjustments are completed so that equipment operates as an integrated system
A-5.01.11P	complete ***documentation***	required ***documentation*** is completed and includes ***system components*** tested, the test results and changes that were completed

RANGE OF VARIABLES

potential includes: electrical, kinetic, mechanical, radio-active, 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

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, site visit log, commissioning documents, design and manufacturers' specifications

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-5.01.01L	demonstrate knowledge of commissioning and its purpose	identify ***hazards*** and describe safe work practices pertaining to commissioning systems or equipment
		identify the purpose of commissioning and the types of systems and equipment requiring them
		identify and interpret ***information sources*** and ***documentation*** pertaining to the commissioning of systems or equipment
		identify ***diagnostic and test equipment*** for the purpose of commissioning systems

RANGE OF VARIABLES

hazards include: arc flash/blast, moving and rotating equipment, electric shocks, potential

information sources include: O&M manuals, single line diagrams, schematics, panel schedules, CEC Z460, Z320, Z462 and Z463

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

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

A-5.02 Performs shutdown and startup procedures

Essential Skills Document Use, Thinking, Working with Others

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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	***system equipment*** is identified and its ***energy sources*** are locked out and tagged out
A-5.02.03P	apply temporary safety ground on shutdown, and remove on startup	temporary safety grounds are used and removed according to AHJ, CEC, job requirements and company policies
A-5.02.04P	test cables and conductors for ground faults and phase identification	cables and conductors are tested with an insulation resistance tester and continuity tester
A-5.02.05P	verify busbar connections and torquing of bolts	busbars are torqued according to manufacturers' specifications
A-5.02.06P	follow specifications sequence for startup	system is energized according to job specifications, type of system and manufacturers' specifications
A-5.02.07P	identify ***system equipment*** that needs to be energized	***system equipment*** is identified and its source of supply is verified by ***documentation***
A-5.02.08P	notify required personnel of shutdown and startup procedures	personnel is 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, radio-active, thermal, hydraulic, pneumatic, gravity

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-5.02.01L	demonstrate knowledge of shutdown and startup procedures and their purpose	identify ***hazards*** and describe safe work practices pertaining to starting up and shutting down systems or equipment
		identify the purpose of starting up and shutting down and the types of systems and equipment requiring it
		identify and interpret ***information sources*** and documentation pertaining to the starting up and shutting down of systems or equipment

RANGE OF VARIABLES

hazards include: arc flash/blast, moving and rotating equipment, electric shocks, uncontrolled release of energy

information sources include: O&M manuals, single line diagrams, schematics, panel schedules, CEC Z460, Z320, Z462 and Z463, AHJ

A-5.03 Decommissions systems

Essential Skills Thinking, Working with Others, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
A-5.03.01P	check documentation for inter-related systems	inter-related systems are identified 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 ***equipment feed*** from distribution source	***equipment feed*** is disconnected and removed
A-5.03.04P	confirm system is de-energized	system is checked to confirm absence of ***energy sources***

A-5.03.05P	dispose of ***system components***	***system components*** are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
A-5.03.06P	record changes to ***site documentation***	all documents are modified to reflect decommissioning changes

RANGE OF VARIABLES

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

energy sources include: electrical, kinetic, mechanical, radio-active, thermal, hydraulic, pneumatic, gravity

system components include: panels, lamps, ballasts, fixtures, cables, switch gear, transformers, capacitors

site 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 ***hazards*** and describe safe work practices pertaining to decommissioning systems or equipment
		identify ***energy sources*** used in system or equipment being decommissioned
		identify the purpose of decommissioning and the types of systems and equipment requiring them
		identify, interpret and modify ***information sources*** and ***documentation*** pertaining to the decommissioning of systems or equipment
		identify ***diagnostic and test equipment*** for the purpose of decommissioning systems

RANGE OF VARIABLES

hazards include: arc flash/blast, moving and rotating equipment, electric shocks

energy sources include: electrical, kinetic, mechanical, radio-active, thermal, hydraulic, pneumatic, gravity

information sources include: O&M manuals, single line diagrams, schematics, panel schedules, CEC Z460, Z320, Z462 and Z463

documentation includes: AHJ reports, inspection reports, as-built drawings, panel schedules, site visit 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

Essential Skills	Oral Communication, Working with Others, Continuous Learning, Digital Technology

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

SKILLS

	Performance Criteria	Evidence of Attainment
A-6.01.01P	demonstrates communication practices individually or in a group	instructions and messages are understood by all parties involved in communication
A-6.01.02P	listens using ***active listening*** practices	steps of ***active listening*** are utilized
A-6.01.03P	receives and responds to feedback on work	response to feedback indicates understanding and corrective measures are taken
A-6.01.04P	explains and provides feedback	explanation and feedback is provided and task is carried out as directed
A-6.01.05P	uses questioning to improve communication	questions enhance understanding, on-the-job training and goal setting
A-6.01.06P	participates in safety and information meetings	meetings are attended and information is understood 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 the trade
A-6.01.02L	demonstrate knowledge of effective communication practices	describe the importance of using effective verbal and non-verbal communication with ***people in the workplace***

	identify ***sources of information*** to effectively communicate
	identify communication and ***learning styles***
	identify ***personal responsibilities and attitudes*** that contribute to on-the-job success
	identify communication that constitutes ***harassment*** and ***discrimination***

RANGE OF VARIABLES

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

sources of information include: regulations, codes, occupational health and safety requirements, AHJ requirements, prints, drawings, specifications, company and client 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 includes: objectionable conduct, comment or display made either on a one-time or continuous basis that demeans, belittles, or causes personal humiliation or embarrassment to the recipient

discrimination is prohibited based on: race, national or ethnic origin, colour, religion, age, sex, sexual orientation, marital status, family status, disability or conviction for which a pardon has been granted

A-6.02 Uses mentoring techniques

Essential Skills	Oral Communication, Working with Others, Continuous Learning

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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 the objective and point of the lesson
A-6.02.02P	link lesson to other lessons and the job	lesson order and unplanned learning opportunities are defined
A-6.02.03P	demonstrates performance of a skill to an apprentice or learner	***steps required to demonstrate a skill*** are performed
A-6.02.04P	set up conditions required for an apprentice to practice a skill	***practice conditions*** are set up so that the skill can be practiced safely by the apprentice

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 adopts best practice after having been given supportive or corrective feedback
A-6.02.07P	support apprentices in pursuing technical training opportunities	technical training is completed within timeframe prescribed by apprenticeship authority
A-6.02.08P	support equity group apprentices	workplace is harassment and discrimination-free
A-6.02.09P	implement probationary period for learners to assess their suitability to the trade	commitment is demonstrated by the learner and more suitable career options are provided to others

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
A-6.02.01L	identify, explain and demonstrate strategies for learning skills in the workplace	describe the importance of individual experience
		describe the shared responsibilities for workplace learning
		determine one's own learning preferences and explain how these relate to learning new skills
		describe the importance of different types of skills in the workplace
		describe the importance of ***essential skills*** in the workplace
		identify different ways of learning
		identify different ***learning needs*** and strategies to meet ***learning needs***
		identify ***strategies to assist in learning a skill***
A-6.02.02L	identify, explain and demonstrate ***strategies for teaching*** workplace skills	identify different roles played by a workplace mentor
		describe the ***steps*** involved in teaching skills
		explain the importance of identifying the point of a lesson

	identify how to choose a good time to present a lesson
	explain the importance of linking the lessons
	identify the components of the skill (the context)
	describe considerations in setting up opportunities for skill practice
	explain the 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 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, distribution and service systems

TASK B-7 Installs and maintains consumer/supply services and metering equipment

TASK DESCRIPTOR

Service entrance equipment provides power for single-phase and three-phase electrical systems and equipment. Consumer services can provide normal, emergency 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 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 single-phase consumer/supply services and metering equipment

Essential Skills Numeracy, Thinking, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-7.01.01P	determine size and type of ***service, service components*** and ***service conductors***	size and type of ***service components*** and ***service conductors*** are selected according to calculated load, company, client and CEC requirements and site-specific conditions
B-7.01.02P	determine layout, clearance and location of ***service components***	layout allows for ***service components*** to be mounted according to ***supply authority*** standards and CEC requirements

B-7.01.03P	determine trench size and minimum cover requirements	trench size and cover allow for the installation of direct burial cables and underground raceways and are constructed according to the ***supply authority*** standards and CEC requirements
B-7.01.04P	protect ***service components*** for single-phase service	***service components*** are protected from environmental and mechanical damage, and from public access according to the ***supply authority*** standards and CEC requirements
B-7.01.05P	mount and secure ***service components***	***service components*** are securely mounted using ***fasteners*** designed for attachment to the support structure according to ***supply authority*** standards and CEC requirements
B-7.01.06P	install ***service conductors***	***service conductors*** are installed without damage to insulation, without stress and the neutral conductor is identified
B-7.01.07P	terminate ***service conductors***	insulation is removed and conductors are tightened and secured according to manufacturers' specifications and CEC requirements, and antioxidant is applied where required
B-7.01.08P	conduct tests of ***service components, service conductors*** and ***metering equipment***	***service components, service conductors*** and ***metering equipment*** are functional and connected to match the application requirements and facilitate commissioning
B-7.01.09P	identify service information on panels and ***metering equipment***	branch circuits and main overcurrent protection devices are labelled on panel directory and meters are labelled for multi-units
B-7.01.10P	bond non-current carrying metallic ***service components***	metallic ***service components*** are bonded according to ***supply authority*** standard and CEC requirements
B-7.01.11P	ground neutral conductors	neutral conductor is grounded according to ***supply authority*** standards and CEC requirements
B-7.01.12P	bond ***non-electrical metallic piping and structures***	***non-electrical metallic piping and structures*** are bonded according to ***supply authority*** standards, AHJ and CEC requirements
B-7.01.13P	remove and dispose of unserviceable ***service components*** and ***service conductors***	unserviceable ***service components*** and ***service conductors*** are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-7.01.14P	update ***documentation***	***documentation*** 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 supply authority/utility

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

metering equipment includes: meter sockets, current transformers (CTs), voltage transformers (VTs) (previously called potential transformers), enclosures

non-electrical metallic piping and structures include: gas lines, water lines, 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 ***single-phase services*** and their applications	interpret codes and regulations pertaining to ***single-phase services***
		interpret information pertaining to ***single-phase services*** found on drawings and specifications
		interpret ***supply authority*** single-phase standards
		identify types of ***single-phase services*** and describe their characteristics and applications
		identify ***service components, service conductors*** and ***fasteners*** and describe their purpose and applications
		identify the considerations and requirements for selecting the type of ***single-phase services, service components*** and ***service conductors***
B-7.01.02L	demonstrate knowledge of ***single-phase service*** installation methods	identify sources of information and documentation required for the installation of ***single-phase services***
		identify and describe the methods used to install ***single-phase services***, ***service components*** and ***service conductors***
		identify and describe the methods used to connect ***service conductors***
		identify the methods of grounding and bonding ***single-phase services***
B-7.01.03L	demonstrate knowledge of demand load calculations for a ***single-phase service***	identify the method used to calculate demand load
		calculate demand load for a ***single-phase service***

B-7.01.04L	demonstrate knowledge of the 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
supply authority includes: local supply authority (single or three-phase standards), electrical inspectors
service components include: supports, enclosures, raceways, conduit, meter sockets, panels, service mast, point of attachment
service conductors include: wire, cables, conductors
fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints, insulators

B-7.02 Maintains single-phase consumer/supply services and metering equipment

Essential Skills Oral Communication, Thinking, Digital Technology

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-7.02.01P	obtain description of malfunction from user	malfunction issues and information are collected and documented
B-7.02.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-7.02.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-7.02.04P	determine course of action	course of action is identified based on the 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	equivalent replacement components (OEM replacement when mandated) are selected
B-7.02.07P	install replacement components	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 by consequence of failure, commissioning documentation and manufacturers' recommendations
B-7.02.09P	create maintenance schedule	maintenance schedule is created by considering 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 using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and test results are 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

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 knowledge of the methods used to maintain single-phase services	describe the methods used to maintain single-phase services and their components
B-7.02.02L	demonstrate knowledge of the theory of single-phase systems	describe theory of single phase three-wire system
		describe single-phase circuit fundamentals

B-7.03 Installs three-phase consumer/supply services and metering equipment

Essential Skills Numeracy, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-7.03.01P	determine size and type of ***service, service components*** and ***service conductors***	size and type of ***service components*** and ***service conductors*** are selected according to calculated load, company, client and CEC requirements and site-specific conditions
B-7.03.02P	determine layout, clearance and location of ***service components***	layout allows for ***service components*** to be mounted according to the ***supply authority*** standards and CEC requirements
B-7.03.03P	determine trench size and minimum cover requirements	trench size and cover allows for the installation of direct burial cables and underground raceways, and are constructed according to the ***supply authority*** standards and CEC requirements
B-7.03.04P	protect ***service components*** for three-phase service	***service components*** are protected from environmental and mechanical damage, and from public access according to the ***supply authority*** standards and CEC requirements
B-7.03.05P	mount and secure ***service components***	***service components*** are securely mounted using ***fasteners*** designed for attachment to the support structure according to ***supply authority*** standards and CEC requirements
B-7.03.06P	install ***service conductors***	***service conductors*** are installed without damage to insulation, without stress, and the neutral is identified and three-phase conductors are colour-coded
B-7.03.07P	terminate ***service conductor***	insulation is removed and conductors are tightened and secured according to manufacturers' specifications and CEC requirements, and antioxidant is applied where required
B-7.03.08P	conduct tests of ***service components, service conductors*** and ***metering equipment***	***service components, service conductors*** and ***metering equipment*** are functional and connected to match the application requirements and facilitate commissioning

B-7.03.09P	identify service information on ***metering equipment***, main disconnect and panels	branch circuits and main overcurrent protection devices are labelled on panel directory and meters are labelled for multi-units
B-7.03.10P	bond non-current carrying metallic ***service components***	metallic ***service components*** are bonded according to ***supply authority*** standards and CEC requirements
B-7.03.11P	ground neutral conductor	neutral conductor is grounded according to ***supply authority*** standard and CEC requirements
B-7.03.12P	bond ***non-electrical metallic piping and structures***	***non-electrical metallic piping and structures*** are bonded according to ***supply authority*** standards, AHJ and CEC requirements
B-7.03.13P	remove and dispose of unserviceable ***service components*** and ***service conductors***	unserviceable ***service components*** and ***service conductors*** are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-7.03.14P	update ***documentation***	***documentation*** 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, 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, insulators

metering equipment includes: meter sockets, CTs, VTs, enclosures

non-electrical metallic piping and structures include: gas lines, water lines, 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 ***three-phase services*** and their applications	interpret codes and regulations pertaining to ***three-phase services***
		interpret information pertaining to ***three-phase services*** found on drawings and specifications
		identify types of ***three-phase services*** and describe their characteristics and applications

		identify ***service components, service conductors*** and ***fasteners*** and describe their purpose and applications
		interpret supply authority three-phase standards
		identify the considerations and requirements for selecting the type of ***three-phase services, service components*** and ***service conductors***
B-7.03.02L	demonstrate knowledge of ***three-phase service*** installation methods	identify sources of information and documentation required for the installation of ***three-phase services***
		identify and describe the methods used to install ***three-phase services***, ***service components*** and ***service conductors***
		identify and describe the methods used to connect ***service conductors***
		identify the methods of grounding and bonding ***three-phase services***
		identify ground fault and ground detection type protection systems
B-7.03.03L	demonstrate knowledge of demand load calculations for a ***three-phase service***	identify the method used to calculate demand load
		calculate demand load for a ***three-phase service***
B-7.03.04L	demonstrate knowledge of the theory 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, meter sockets, 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, insulators

B-7.04 Maintains three-phase consumer/supply services and metering equipment

Essential Skills Oral Communication, Thinking, Digital Technology

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-7.04.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-7.04.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-7.04.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-7.04.04P	determine course of action	course of action is identified based on the 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	equivalent replacement components (OEM replacement when mandated) are selected
B-7.04.07P	install replacement components	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 by consequence of failure, commissioning documentation and manufacturers' recommendations
B-7.04.09P	create maintenance schedule	maintenance schedule is created by considering 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 using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and test results are 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

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 (time domain reflectometer), non-contact infrared sensors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-7.04.01L	demonstrate knowledge of the methods used to maintain three-phase service	describe the methods used to maintain three-phase services and their components
B-7.04.02L	demonstrate knowledge of the theory of three-phase systems	describe three-phase circuit fundamentals

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 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 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.

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

B-8.01 Installs overcurrent protection devices

Essential Skills	Document Use, Numeracy, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-8.01.01P	determine type and rating of ***overcurrent protection device***	type and rating of ***overcurrent protection device*** is determined according to CEC requirements and manufacturers’ specifications
B-8.01.02P	determine type and size of ***enclosures***	***enclosure*** type and size is based on overcurrent protection device, environment and type of equipment
B-8.01.03P	secure ***overcurrent protection devices***	devices are mounted and secured to enclosures and/or busbars using ***hardware*** designed for the equipment
B-8.01.04P	terminate ***overcurrent protection devices***	***overcurrent protection devices*** are connected to the line and load terminals according to manufacturers’ specifications and CEC requirements
B-8.01.05P	set trip settings and ensure protection is coordinated	trip settings are based on load requirements, coordination studies and CEC requirements

B-8.01.06P	update ***documentation*** and labels	branch and distribution circuits are labelled on directories and other ***documentation***
B-8.01.07P	remove and dispose of unserviceable ***enclosures***, ***overcurrent protection devices*** and ***hardware***	unserviceable ***enclosures***, ***overcurrent devices*** and ***hardware*** are disposed of according to jurisdictional and federal legislations, and waste disposal requirements
B-8.01.08P	test device	***overcurrent protection devices*** are tested according to manufacturers' specifications
B-8.01.09P	update ***documentation***	***documentation*** 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 ***overcurrent protection devices***, their applications and operation	interpret codes and regulations pertaining to ***overcurrent protection devices***
		interpret information pertaining to ***overcurrent protection devices*** found on drawings and specifications
		explain the purpose and operation of ***overcurrent protection devices***
		explain the effects of short-circuit current and describe the associated damage to the circuit
		identify types of ***overcurrent protection devices*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***overcurrent protection devices***
		explain the purpose of coordination studies
B-8.01.02L	demonstrate knowledge of the procedures used to install ***overcurrent protection devices***	describe the procedures used to install ***overcurrent protection devices***

	explain the purpose of updating ***documentation***
	explain the procedures used 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

Essential Skills Oral Communication, Thinking, Digital Technology

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-8.02.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-8.02.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-8.02.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-8.02.04P	determine course of action	course of action is identified based on the type of malfunction and availability of replacement parts
B-8.02.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-8.02.06P	install replacement components	equivalent replacement components are installed according to as-built or equivalent specifications with minimal disruptions
B-8.02.07P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' recommendations
B-8.02.08P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation

B-8.02.09P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.02.10P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule, and test results are documented
B-8.02.11P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-8.02.12P	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, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, load banks, circuit breaker tester, non-contact infrared sensors

KNOWLEDGE

	Learning Outcomes	Learning Objectives
B-8.02.01L	demonstrate knowledge of the methods and theory used to maintain overcurrent protection devices	describe the methods and theory used to maintain overcurrent protection devices

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

Essential Skills Numeracy, Thinking, Document use

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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, ***application***, and company, client and CEC requirements
B-8.03.02P	determine type of ***ground fault protection device*** to use	***ground fault protection devices*** are determined according to load, location, ***application***, and company, client and CEC requirements

B-8.03.03P	determine type of ***arc fault protection device*** to use	***arc fault protection devices*** are determined according to load, location, ***application***, and company, client and CEC requirements
B-8.03.04P	determine type of ***surge protection device*** to use	***surge protection devices*** are determined according to installation requirements, ***application***, and company, client and CEC requirements
B-8.03.05P	mount protection devices	devices are mounted and secured using ***hardware*** designed for the equipment
B-8.03.06P	terminate protection devices	conductors are terminated by removing the insulation and tightening and securing them according to manufacturers' specifications and CEC requirements
B-8.03.07P	update ***documentation*** and labels	branch circuits and distribution circuits are labelled on directories and other ***documentation***
B-8.03.08P	remove and dispose of unserviceable protection devices	unserviceable ***ground fault protection devices, arc fault protection devices*** and ***surge protection devices*** are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-8.03.09P	set and test device	***ground fault protection devices, arc fault protection devices*** and ***surge protection devices*** are set and tested according to specifications
B-8.03.10P	update ***documentation***	***documentation*** 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: arc fault circuit interrupter (AFCI) receptacles, AFCI breakers

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

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-8.03.01L	demonstrate knowledge of ***ground fault, arc fault*** and ***surge protection devices***, their applications and operation	interpret codes and regulations pertaining to ***ground fault, arc fault*** and ***surge protection devices***
		interpret information pertaining to ***ground fault, arc fault*** and ***surge protection devices*** found on drawings and specifications
		explain the purpose and operation of ***ground fault, arc fault*** and ***surge protection devices***
		identify types of ***ground fault, arc fault*** and ***surge protection devices*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***ground fault, arc fault*** and ***surge protection devices***
B-8.03.02L	demonstrate knowledge of the procedures used to install ***ground fault, arc fault*** and ***surge protection devices***	describe the procedures used to install ***ground fault, arc fault*** and ***surge protection devices***
		explain the purpose of updating ***documentation***

RANGE OF VARIABLES

ground fault protection devices include: GFCI receptacles, GFCI breakers
arc fault protection devices include: AFCI receptacles, AFCI breakers
surge protection devices include: MOV, zener diodes, thyristors, surge suppressors
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

Essential Skills Oral Communication, Digital Technology, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-8.04.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-8.04.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-8.04.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-8.04.04P	determine course of action	course of action is identified based on the type of malfunction and availability of replacement parts
B-8.04.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-8.04.06P	install replacement components	equivalent replacement components are installed according to as-built or manufacturers' specifications with minimal disruptions
B-8.04.07P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' recommendations
B-8.04.08P	create maintenance schedule	maintenance schedule is created by considering maintenance documentation and requirements, and manufacturers' specifications
B-8.04.09P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.04.10P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule, and test results are documented
B-8.04.11P	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, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, non-contact infrared sensors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-8.04.01L	demonstrate knowledge of the methods and theory used to maintain ground fault, arc fault and surge protection devices	describe the methods and theory used to maintain ground fault protection devices
		describe the methods and theory used to maintain arc fault protection devices
		describe the methods and theory used to maintain surge protection devices

B-8.05 Installs under and over voltage protection devices

Essential Skills Document Use, Reading, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-8.05.01P	determine type of ***under and over voltage protection devices*** to use	***under and over voltage protection devices*** are determined according to installation requirements and CEC
B-8.05.02P	mount ***under and over voltage protection devices***	devices are mounted and secured using ***hardware*** designed for the equipment
B-8.05.03P	connect ***under and over voltage protection devices***	***under and over voltage protection devices*** are connected to the circuit according to specifications and CEC
B-8.05.04P	set and test ***under and over voltage protection devices***	***under and over voltage protection devices*** are set and tested according to manufacturers' specifications
B-8.05.05P	update ***documentation***	***documentation*** is updated to reflect changes carried out

RANGE OF VARIABLES

under and over voltage protection devices include: under voltage devices, protective relays, sensors
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 ***under and over voltage protection devices***, their applications and operation	interpret information pertaining to ***under and over voltage protection devices*** found on drawings and specifications
		explain the purpose and operation of ***under and over voltage protection devices***
		identify types of ***under and over voltage protection devices*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***under and over voltage protection devices***
B-8.05.02L	demonstrate knowledge of the procedures used to install ***under and over voltage protection devices***	describe the procedures used to install ***under and over voltage protection devices***
		explain the purpose of updating ***documentation***

RANGE OF VARIABLES

under and over voltage protection devices include: under voltage devices, over voltage devices
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

Essential Skills Oral Communication, Digital Technology, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-8.06.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-8.06.02P	consult drawings and documentation	drawings and documentation are consulted prior to performing field assessments
B-8.06.03P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to ensure the device operates according to manufacturers' specifications
B-8.06.04P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-8.06.05P	determine course of action	course of action is identified based on the type of malfunction and availability of replacement parts
B-8.06.06P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected according to availability
B-8.06.07P	install replacement components	equivalent replacement components are installed according to as-built or manufacturers' specifications with minimal disruptions
B-8.06.08P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' specifications
B-8.06.09P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation and manufacturers' specifications
B-8.06.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.06.11P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule, and test results are documented

B-8.06.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-8.06.13P	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, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, panel meter calibrator, non-contact infrared sensor

KNOWLEDGE		
	Learning Outcomes	**Learning Objectives**
B-8.06.01L	demonstrate knowledge of the procedures used to maintain under and over voltage protection devices	describe the procedures used to maintain under voltage protection devices
		describe the procedures used to maintain over voltage protection devices
		explain the purpose of updating ***documentation***

RANGE OF VARIABLES

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 over 30 and up to 750 volts. This equipment allows for safe utilization of electricity. This task does not include distribution systems for Class 1 and Class 2 systems.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Document Use, Thinking, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-9.01.01P	determine size and type of ***low voltage power distribution equipment*** and type of ***enclosure***	size and type of ***low voltage power distribution equipment*** are selected based on CEC calculated load, company and client requirements, site-specific conditions and drawings
B-9.01.02P	determine layout and location of ***low voltage power distribution equipment***	***low voltage power distribution equipment*** are laid according to drawings, manufacturers’ specifications and CEC requirements
B-9.01.03P	install and secure ***low voltage power distribution equipment***	***low voltage power distribution equipment*** is securely mounted to the structure according to manufacturers’ specifications, CEC requirements and drawings/documentation
B-9.01.04P	install feeder and supply conductors	feeder and supply conductors are installed according to CEC requirements and without damage to insulation, without stress, and the neutral is identified and conductors are colour-coded
B-9.01.05P	terminate feeder and supply conductor connections	conductors are terminated by removing the insulation, applying antioxidant where required, and tightening and securing them according to manufacturers’ specifications and CEC requirements

B-9.01.06P	conduct tests of ***low voltage power distribution equipment*** and feeders	***low voltage power distribution equipment*** and feeders are functional and connected to match the application requirements
B-9.01.07P	identify information on ***low voltage power distribution equipment***	***low voltage power distribution equipment*** is labelled according to job, company and client requirements
B-9.01.08P	remove and dispose of unserviceable ***low voltage power distribution equipment***	unserviceable ***low voltage power distribution equipment***, ***enclosures***, and feeder and supply conductors are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-9.01.09P	update ***documentation***	***documentation*** 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, 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 ***low voltage power distribution equipment***, their applications and operation	interpret codes and regulations pertaining to ***low voltage power distribution equipment***
		interpret information pertaining to ***low voltage power distribution equipment*** found on drawings and specifications
		identify types of ***low voltage power distribution equipment*** and describe their characteristics and applications
		identify the ***considerations*** and requirements for selecting ***low voltage power distribution equipment*** and ***enclosures***
B-9.01.02L	demonstrate knowledge of the procedures used to install ***low voltage power distribution equipment***	describe the procedures used to install ***low voltage power distribution equipment***
		describe the procedures used 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, racking equipment, CTs, VTs, busbars, splitters, MCCs, transformers
considerations include: load, voltage ratings, required circuit capacity, arc fault study
enclosures include: CSA enclosures, enclosures for hazardous locations

B-9.02 Maintains low voltage distribution equipment

Essential Skills Digital Technology, Thinking, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-9.02.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-9.02.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-9.02.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-9.02.04P	determine course of action	course of action for the type of malfunction is identified according to 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	equivalent replacement components (OEM replacement when mandated) are selected according to availability
B-9.02.07P	install replacement components	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 by consequence of failure, commissioning documentation and manufacturers' specifications
B-9.02.09P	create maintenance schedule	maintenance schedule is created by considering 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 using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule, and test results are 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

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 the methods used to maintain ***low voltage distribution equipment***	describe the methods to maintain ***low voltage distribution equipment*** and their components

RANGE OF VARIABLES

low voltage distribution equipment includes: panels, sub-panels, PDCs, switchboards, breakers, fuses, disconnects, 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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Thinking, Numeracy, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-10.01.01P	analyze system to assess ***conditions*** that require power conditioning	voltage and power quality characteristics that are outside of the standard are identified
B-10.01.02P	identify type of power conditioning required	type of power conditioning is identified according to system requirements and local supply authority
B-10.01.03P	perform calculations to size power conditioning and UPS ***components***	***components*** are sized for the requirements of the application
B-10.01.04P	install ***components***	***components*** are securely installed according to manufacturers’ specifications and CEC requirements, and mounted matching building lines using ***fasteners*** designed for the attachment to the material of the support structure
B-10.01.05P	terminate and interconnect ***components***	***components*** are terminated and interconnected according to electrical drawings and specifications, job and CEC requirements
B-10.01.06P	analyze system output to ensure effectiveness of power conditioning installation	test results reflect improved power quality

B-10.01.07P	conduct tests of power conditioning and UPS after installation and record results	power conditioning and UPS is functional and connected to match the application requirements
B-10.01.08P	remove and dispose of unserviceable power conditioning and UPS components	unserviceable equipment is disposed of according to jurisdictional and federal legislation, with minimal impact to the environment
B-10.01.09P	update ***documentation***	***documentation*** 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, insulators

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 types of power conditioning and UPS 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 the types of ***power factor correction equipment*** and describe their characteristics, applications and operation
		identify ***equipment used to reduce harmonics*** in power distribution systems and describe their characteristics, applications and operation
		identify types of ***UPS equipment*** used in power distribution system conditioning and describe their characteristics, applications and operation
B-10.01.02L	demonstrate knowledge of procedures used to install power conditioning and UPS systems	describe the procedures used to install power conditioning and UPS systems
		identify hazards with UPS systems when working with batteries, multiple energy sources and capacitors

RANGE OF VARIABLES

power factor correction equipment includes: synchronous condensers (motors), reactors, capacitors
equipment used to reduce harmonics includes: passive and active filters, transformers and capacitors
UPS equipment includes: online, offline, online interactive, maintenance bypass and static bypass, battery systems

B-10.02 Maintains power conditioning systems

Essential Skills Digital Technology, Thinking, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-10.02.01P	obtain description of trouble from user	malfunction issues and ***information*** are collected and documented
B-10.02.02P	conduct ***field assessments***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-10.02.03P	determine sources of malfunction based on ***field assessment***	sources of malfunction are identified
B-10.02.04P	determine course of action	course of action for the type of malfunction is identified according to availability of replacement parts
B-10.02.05P	repair malfunctioning ***components***	repaired ***components*** are operational
B-10.02.06P	select replacement ***components***	equivalent replacement ***components*** (OEM replacement when mandated) are selected according to availability
B-10.02.07P	install replacement ***components***	equivalent replacement ***components*** 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 after repair	power conditioning, UPS and surge suppression systems are functional and connected to match the application requirements
B-10.02.09P	***clean, lubricate and adjust*** components	power conditioning, UPS and surge suppression system ***components*** are restored to optimal conditions
B-10.02.10P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' specifications

B-10.02.11P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation, and manufacturers' specifications
B-10.02.12P	record tests in maintenance schedule	operational problems are identified 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: log books, manufacturers' manuals, standard operating procedures, details from user, incident reports

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, transformers, capacitors, shunt coils, diodes, reactors, synchronous condensers (motors), filters, fuses, UPS

cleaning, lubricating and adjusting procedures include: cleaning fans and filters, lubricating bearings and bushings, load testing batteries, adjusting cabinets and door seals

KNOWLEDGE

	Learning Outcomes	Learning Objectives
B-10.02.01L	demonstrate knowledge of the methods used to maintain power conditioning systems	describe the methods to maintain power conditioning systems and their ***components***

RANGE OF VARIABLES

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

TASK B-11 Installs and maintains bonding, grounding and ground fault detection systems

TASK DESCRIPTOR

Bonding and grounding systems are used to protect life and equipment from transient and fault current. Ground fault detections systems are used to detect electrical current leakage and, in three phase systems, are also used to indicate a single phase ground.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Thinking, Document Use, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-11.01.01P	determine type of ***grounding electrodes***	***grounding electrodes*** are determined based on site-specific conditions, CEC requirements and engineering specifications
B-11.01.02P	determine grounding conductor size	conductor size is determined based on supply voltage, CEC requirements and engineering specifications
B-11.01.03P	determine layout and location of ***grounding system components***	layout allows for installation of grounding electrodes, routing of the grounding conductor, and point of termination at the source of supply and service equipment according to CEC requirements and supply authority
B-11.01.04P	install ***grounding system components***	***grounding system components*** are installed according to layout, drawings, site conditions, AHJ and CEC requirements
B-11.01.05P	terminate and interconnect ***grounding system components***	***grounding system components*** are terminated and interconnected according to drawings, AHJ and CEC requirements

B-11.01.06P	perform ground resistance and continuity tests	ground resistance and continuity tests are performed using ***ground testing equipment*** and documented
B-11.01.07P	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

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
		identify grounding conductors, equipment and components, and describe their characteristics and applications
		identify the considerations and requirements for selecting grounding conductors, methods, equipment and components
		explain the purpose of grounding
		explain the differences between grounding and bonding, and identify situations where interconnection is required
B-11.01.02L	demonstrate knowledge of the procedures used to install grounding systems	describe the procedures used to install grounding systems
		describe the method used to determine grounding conductor size

B-11.02 Maintains grounding systems

Essential Skills Thinking, Digital Technology, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-11.02.01P	obtain description of trouble from user	malfunction issues and ***information*** are collected and documented
B-11.02.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-11.02.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-11.02.04P	determine course of action	course of action for the type of malfunction is identified
B-11.02.05P	repair malfunctioning ***grounding system components***	repaired ***grounding system components*** are operational
B-11.02.06P	select replacement ***grounding system components***	equivalent replacement ***grounding system components*** (OEM replacement when mandated) are selected according to availability
B-11.02.07P	install replacement ***grounding system components***	equivalent replacement ***grounding system components*** are installed according to as-built or manufacturers' specifications and CEC with minimal disruptions
B-11.02.08P	conduct tests	tests are conducted using ***diagnostic and test equipment*** according to established maintenance schedule and commissioning documentation, and test results are documented
B-11.02.09P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-11.02.10P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' specifications
B-11.02.11P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation, and manufacturers' specifications

B-11.02.12P	follow maintenance schedule	maintenance tasks are done according to established schedule and documented
B-11.02.13P	update maintenance log	maintenance log is updated to reflect tasks performed

RANGE OF VARIABLES

information includes: log books, manufacturers' manuals, standard operating procedures, details from user, incident reports

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

KNOWLEDGE

	Learning Outcomes	Learning Objectives
B-11.02.01L	demonstrate knowledge of the methods used to maintain grounding systems	describe the methods used to maintain grounding systems and their ***components*** according to AHJ and CEC requirements

RANGE OF VARIABLES

grounding system components include: grounding electrodes, grounding conductors, grounding connectors

B-11.03 Installs bonding systems

Essential Skills Thinking, Document Use, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-11.03.01P	determine bonding method	bonding method is determined based on environment, amperage, voltage, mechanical protection, and conductor material and size
B-11.03.02P	determine bonding conductor size	conductor size is determined based on CEC requirements and engineering specifications

B-11.03.03P	determine layout and location of ***bonding components***	***bonding components*** are laid out according to drawings, manufacturers' specifications and CEC requirements
B-11.03.04P	install ***bonding components***	***bonding components*** are installed to ensure continuity between non-current carrying components of electrical systems and other metallic components (equipotential plane), and to facilitate the function of overcurrent devices (fault current), according to layout, site conditions, drawings, AHJ and CEC requirements
B-11.03.05P	terminate and interconnect ***bonding components***	***bonding components*** are terminated and interconnected according to drawings and specifications, AHJ and CEC requirements
B-11.03.06P	perform continuity and resistance tests	continuity and resistance tests are performed using ***testing equipment*** and documented
B-11.03.07P	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, 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
		identify bonding conductors, equipment and components, and describe their characteristics and applications
		identify the considerations and requirements for selecting bonding conductors, methods, equipment and components
		explain the purpose and differences between grounding and bonding, and identify situations where interconnection is required
B-11.03.02L	demonstrate knowledge of the procedures used to install bonding systems	describe the procedures used to install bonding systems
		describe the method used to determine bonding conductor size

B-11.04 Maintains bonding systems

Essential Skills	Thinking, Digital Technology, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-11.04.01P	obtain description of trouble from user	malfunction issues and ***information*** are collected and documented
B-11.04.02P	conduct ***field assessment***	***diagnostic and test equipment*** is used to conduct ***field assessments*** to detect malfunctions
B-11.04.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-11.04.04P	determine course of action	course of action for the type of malfunction is identified
B-11.04.05P	repair malfunctioning ***bonding components***	repaired ***bonding components*** are operational according to the CEC
B-11.04.06P	select replacement ***bonding components***	equivalent replacement ***bonding components*** are selected
B-11.04.07P	install replacement ***bonding components***	replacement ***bonding components*** are installed with minimal disruptions according to the CEC
B-11.04.08P	conduct tests	tests are conducted using ***diagnostic and test equipment*** according to established maintenance schedule and commissioning documentation, and test results are documented
B-11.04.09P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-11.04.10P	determine maintenance requirements	maintenance requirements are identified by manufacturers' specifications, and company and client policies
B-11.04.11P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation
B-11.04.12P	follow maintenance schedule	maintenance tasks are done according to established schedule and documented
B-11.04.13P	update maintenance log	maintenance log is updated to reflect tasks performed

RANGE OF VARIABLES

information includes: log books, manufacturers' manuals, standard operating procedures, details from user, incident reports

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, lock nuts, terminations

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-11.04.01L	demonstrate knowledge of the methods used to maintain bonding systems	describe the methods used to maintain bonding systems and their components according to AHJ and CEC requirements

B-11.05 Installs ground fault detection systems

Essential Skills Thinking, Document Use, Reading

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-11.05.01P	determine requirement and type of ***ground fault detection system***	requirement and type of ***ground fault detection system*** are based on site-specific conditions, AHJ, CEC requirements, drawings and specifications, and company and client specifications
B-11.05.02P	determine layout and location of ***ground fault detection system components***	***ground fault detection system components*** are laid out according to drawings, manufacturers' specifications, company and client specifications, and CEC requirements
B-11.05.03P	mount ***ground fault detection system components***	***ground fault detection system components*** are mounted using ***fasteners*** designed for the attachment to the material of the support structure according to drawings, manufacturers' specifications and CEC requirements

B-11.05.04P	terminate and interconnect ***ground fault detection system components***	***ground fault detection system components*** are terminated and interconnected according to drawings, manufacturers' specifications and CEC requirements
B-11.05.05P	set parameters for ***ground fault detection system***	parameters are set to indicate as required according to type of ***ground fault detection system*** installed, manufacturers' specifications, CEC requirements and coordination studies
B-11.05.06P	test operation of ***ground fault detection systems***	***ground fault detection systems*** are tested according to manufacturers' specifications, and results are documented
B-11.05.07P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

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

ground fault 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)

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

KNOWLEDGE

	Learning Outcomes	Learning Objectives
B-11.05.01L	demonstrate knowledge of ***ground fault detection systems*** and their operation	identify types of ***ground fault detection systems*** and describe their characteristics and applications
		explain the purpose of ***ground fault detection systems***
		interpret codes, drawings, specifications and regulations pertaining to ***ground fault detection systems***
		identify the considerations and requirements for selecting the type of ***ground fault detection system components***
B-11.05.02L	demonstrate knowledge of ***ground fault detection systems*** installation methods	identify and describe the methods used to install ***ground fault detection systems*** and their components

RANGE OF VARIABLES

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

ground fault 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)

B-11.06 Maintains ground fault detection systems

Essential Skills Thinking, Digital Technology, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-11.06.01P	obtain description of trouble from user	malfunction issues and ***information*** are collected and documented
B-11.06.02P	conduct ***field assessment***	***diagnostic and test equipment*** are used to conduct ***field assessments*** to detect failures
B-11.06.03P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-11.06.04P	determine course of action	course of action for the type of malfunction is identified using manufacturers' specifications and documents
B-11.06.05P	repair malfunctioning ***ground fault detection system components***	repaired ***ground fault detection system components*** are operational according to CEC
B-11.06.06P	select replacement ***ground fault detection system components***	equivalent replacement ***ground fault detection system components*** (OEM replacement when mandated) are selected
B-11.06.07P	install replacement ***ground fault detection system components***	replacement system ***components*** are installed according to as-built or manufacturers' specifications and CEC with minimal disruptions
B-11.06.08P	conduct tests	tests are conducted using ***diagnostic and test equipment*** according to manufacturers' specifications and established maintenance schedule, and test results are 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 by consequence of failure, commissioning documentation and manufacturers' specifications
B-11.06.11P	create maintenance schedule	maintenance schedule is created by considering 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: log books, manufacturers' manuals, standard operating procedures, details from user, incident reports

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

ground fault 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)

KNOWLEDGE

	Learning Outcomes	Learning Objectives
B-11.06.01L	demonstrate knowledge of the methods used to maintain ***ground fault detection systems***	describe the methods used to maintain ***ground fault detection systems*** and their ***components*** according to manufacturers' specifications

RANGE OF VARIABLES

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

ground fault 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)

TASK B-12 Installs and maintains power generating 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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Thinking, Numeracy, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-12.01.01P	determine power requirements for the application by performing load calculations and tests	power requirements are determined using connected load and CEC requirements
B-12.01.02P	determine the type and capacity of ***AC generating systems*** and ***AC generating system components*** to be installed for the application	type and capacity of ***AC generating systems*** and ***AC generating system components*** meet the application requirements
B-12.01.03P	position and mount ***AC generating systems*** and ***AC generating system components***	***AC generating system*** is positioned according to manufacturers’ and job specifications and AHJ requirements
B-12.01.04P	terminate and interconnect ***AC generating systems*** and ***AC generating system components***	***AC generating systems*** and ***AC generating system components*** are terminated and interconnected according to drawings, specifications and job, local supply authority and CEC requirements
B-12.01.05P	ground and bond ***AC generating systems*** and ***AC generating system components***	***AC generating system*** and ***AC generating system components*** are grounded and bonded according to CEC requirements
B-12.01.06P	program ***AC generating systems*** and controls for shutdown and startup sequences	***AC generating system*** is programmed and meets functionality and established parameters and test results are documented

B-12.01.07P	conduct tests of ***AC generating systems*** and ***AC generating system components***	***AC generating systems*** and ***AC generating system components*** are tested according to manufacturers' specifications and test results are documented
B-12.01.08P	disconnect existing ***AC generating systems*** and ***AC generating system components*** and update documentation	***AC generating systems*** and ***AC generating system components*** are disconnected, remaining installations are terminated according to CEC requirements and documentation is updated
B-12.01.09P	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, AVR, governor

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-12.01.01L	demonstrate knowledge of ***AC generating systems*** and ***AC generating system components***, their applications and operation	describe ***AC generating system components*** and explain their operating principles
		identify types of ***AC generating systems*** and describe their characteristics and applications
		identify ***AC generating system components*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***AC generating systems*** and ***AC generating system components***
		interpret information pertaining to ***AC generating systems*** found on drawings and specifications
		interpret codes, standards and regulations pertaining to ***AC generating systems***
B-12.01.02L	demonstrate knowledge of the procedures used to install ***AC generating systems***	describe the procedures used to install ***AC generating systems*** and ***AC generating system components***

		describe the procedures used to control the output voltage, phase sequencing and frequency of AC generators
B-12.01.03L	demonstrate knowledge of the procedures used to interconnect ***AC generating systems*** with standalone or parallel operations	describe the procedure used to interconnect AC generating systems 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

B-12.02 Maintains AC generating systems

Essential Skills Reading, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-12.02.01P	obtain description of operation and malfunction of ***AC generating system***	required information about equipment operation is gathered from end user
B-12.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic equipment and test equipment*** results
B-12.02.03P	identify and remove defective ***AC generating system components***	defective ***AC generating system component*** is removed without damage to system or other components
B-12.02.04P	repair malfunctioning ***AC generating system components***	repaired ***AC generating system components*** are operational
B-12.02.05P	select replacement ***AC generating system components***	replacement ***AC generating system components*** are selected according to the application
B-12.02.06P	install replacement ***AC generating system components***	***AC generating system components*** are installed with minimal disruptions and interruptions
B-12.02.07P	conduct tests of ***AC generating systems*** after repair	***AC generating system*** is tested according to manufacturers' specifications
B-12.02.08P	perform ***maintenance procedures*** to ***AC generating system components***	***AC generating system components*** are restored to optimal conditions

B-12.02.09P	record tests in maintenance log	maintenance log is updated to reflect maintenance tasks performed
B-12.02.10P	compare and analyze maintenance test results	maintenance is performed when required based on analysis of test results and comparison with specifications

RANGE OF VARIABLES

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, AVR, governor

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-12.02.01L	demonstrate knowledge of ***AC generating systems***, their applications and operation	identify types of ***AC generating systems*** and describe their characteristics
		identify ***AC generating system components*** and describe their applications
		interpret codes and regulations pertaining to ***AC generating systems***
		interpret information pertaining to ***AC generating systems*** found on drawings and specifications
		explain operating principles of the ***AC generating system components*** and ***AC generating systems***
		interpret information contained on AC generator nameplates
B-12.02.02L	demonstrate knowledge of procedures used to maintain ***AC generating systems***	describe the procedures used to maintain ***AC generating systems*** and their ***AC generating system components***

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, AVR, governor

B-12.03 Installs direct current (DC) generating systems

Essential Skills Thinking, Numeracy, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-12.03.01P	determine power requirements for the application by performing load calculations and tests	power requirements are determined using connected load and CEC requirements
B-12.03.02P	determine the type and capacity of ***DC generating system*** and ***DC generating system components*** to be installed for the application	type and capacity of ***DC generating systems*** and ***DC generating system components*** meet the application requirements
B-12.03.03P	position and mount ***DC generating systems*** and ***DC generating system components***	***DC generating system*** is positioned according to manufacturers' and job specifications, company and client specifications, and AHJ requirements
B-12.03.04P	terminate and interconnect ***DC generating systems*** and ***DC generating system components***	***DC generating systems*** and ***DC generating system components*** are terminated and interconnected according to drawings and specifications, job, company and client specifications, and CEC requirements
B-12.03.05P	ground and bond ***DC generating systems*** and ***DC generating system components***	***DC generating system*** and ***DC generating system components*** are grounded and bonded according to CEC requirements
B-12.03.06P	program ***DC generating systems*** and controls for shutdown and startup sequences	***DC generating system*** is programmed and meets functionality and established parameters and test results are documented
B-12.03.07P	conduct tests of ***DC generating systems*** and ***DC generating system components***	***DC generating systems*** and ***DC generating system components*** are tested according to manufacturers' specification and test results are documented

B-12.03.08P	disconnect existing ***DC generating systems*** and ***DC generating system components*** and update documentation	***DC generating systems*** and ***DC generating system components*** are disconnected, remaining installations are terminated according to CEC requirements and AHJ, and documentation is updated
B-12.03.09P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

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

DC generating 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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-12.03.01L	demonstrate knowledge of ***DC generating systems*** and ***DC generating system components***, their applications and operation	describe the components of ***DC generating systems*** and explain their operating principles
		identify types of ***DC generators*** and describe their characteristics and applications
		identify ***DC generating system components*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***DC generating systems*** and ***DC generating system components***
		interpret information pertaining to ***DC generating systems*** found on drawings and specifications
		interpret codes, standards and regulations pertaining to ***DC generating systems***
B-12.03.02L	demonstrate knowledge of the procedures used to install and connect ***DC generating systems***	describe the procedures used to install ***DC generating systems*** and ***DC generating system components***
		describe the procedures used to connect ***DC generating systems*** and ***DC generating system components***
		describe the procedures used to control the output voltage of ***DC generators***

RANGE OF VARIABLES

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

DC generating 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

DC generators include: series, shunt, compound

B-12.04 Maintains DC generating systems

Essential Skills Reading, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-12.04.01P	obtain description of operation and malfunction of ***DC generating system***	required information about equipment operation is gathered from end user
B-12.04.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
B-12.04.03P	identify and remove defective ***DC generating system components***	defective ***DC generating system components*** are removed without damage to system or other components
B-12.04.04P	repair malfunctioning ***DC generating system components***	repaired ***DC generating system components*** are operational
B-12.04.05P	select replacement ***DC generating system components***	replacement ***DC generating system components*** match the application
B-12.04.06P	install replacement ***DC generating system components***	***DC generating system components*** are installed with minimal disruptions and interruptions
B-12.04.07P	conduct tests of ***DC generating system*** after repair	***DC generating system*** is tested according to manufacturers' specifications
B-12.04.08P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-12.04.09P	perform ***maintenance procedures*** to ***DC generating system components***	***DC generating system components*** are maintained according to manufacturers' specifications, company and client specifications
B-12.04.10P	record tests in maintenance log	maintenance log is updated to reflect maintenance tasks performed

RANGE OF VARIABLES

DC generating 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 system components include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, disconnecting means

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-12.04.01L	demonstrate knowledge of ***DC generating systems***, their applications and operation	identify types of ***DC generating systems*** and describe their characteristics
		identify ***DC generating system components*** and describe their applications
		interpret codes and regulations pertaining to ***DC generating systems***
		interpret information pertaining to ***DC generating systems*** found on drawings and specifications
		explain operating principles of ***DC generating system components*** and ***DC generating systems***
		interpret information contained on ***DC generator*** nameplates
B-12.04.02L	demonstrate knowledge of procedures used to maintain ***DC generating systems***	describe the procedures used to maintain ***DC generating systems*** and ***DC generating system components***

RANGE OF VARIABLES

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

DC generating system components include: transfer switch, brushes and commutators, prime mover, cables, conductors, overcurrent devices, governors, shaft, armature and stator, bearings, frame, exciter windings

DC generators include: series, shunt, compound

TASK B-13 Installs and maintains renewable energy generating and storage systems

TASK DESCRIPTOR

Renewable energy generating systems can be used to supplement power when power from the utility is unavailable or the building is isolated from the power grid. 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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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 storage systems

Essential Skills Thinking, Continuous Learning, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-13.01.01P	determine energy requirements for the application	calculations are performed according to applicable energy requirements, production requirements, historical data and CEC requirements
B-13.01.02P	determine capacity of ***renewable energy generating system*** to be installed for the application	size and capacity of ***renewable energy generating system*** are determined according to CEC requirements
B-13.01.03P	determine the type of ***renewable energy generating system connection***	***renewable energy generating system connection*** type is determined to be installed for the application
B-13.01.04P	position and mount ***renewable energy generating systems, control system components*** and ***storage system components***	***renewable energy generating systems***, ***control system components*** and ***storage system components*** are securely mounted using ***fasteners*** designed for attachment to the material of the support structure according to company and client specifications, manufacturer specifications, AHJ and CEC

B-13.01.05P	terminate and interconnect ***renewable energy generating system*** and ***control system components***	***renewable energy generating system*** and ***control system components*** are terminated and interconnected according to drawings and specifications, manufacturers' specifications, job and CEC requirements and local supply authority
B-13.01.06P	conduct tests of ***renewable energy generating system*** after installation and record results	***renewable energy generating system*** is functional and connected according to the application requirements and manufacturers' specifications
B-13-01.07P	determine grounding and bonding requirements	method and materials for system grounding and bonding are selected for renewable energy systems according to CEC requirements and AHJ
B-13-01.08P	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

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

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects

storage system components include: pumped hydro, compressed air energy storage, batteries (various technologies)

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-13.01.01L	demonstrate knowledge of ***renewable energy generating systems***, their applications and operation	identify types of ***renewable energy generating systems*** and describe their characteristics, applications and operation
		identify renewable energy system components and describe their characteristics, applications and operation
		identify types of ***renewable energy generating system connections***
		identify types of renewable energy generating ***storage system components***
		interpret codes and regulations pertaining to ***renewable energy generating systems***

B-13.01.02L	demonstrate knowledge of procedures to install and connect ***renewable energy generating systems*** and ***control system components***	describe the procedures used to install ***renewable energy generating systems*** and ***control system components***
		describe the procedures used to connect ***renewable energy generating systems*** and ***control system components***

RANGE OF VARIABLES

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

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

storage system components include: pumped hydro, compressed air energy storage, batteries (various technologies)

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects

B-13.02 Maintains renewable energy generating and storage systems

Essential Skills	Thinking, Continuous Learning, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-13.02.01P	obtain description of operation and malfunction of ***renewable energy generating systems***	required information about equipment operation is gathered from end user
B-13.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results to determine source of malfunction
B-13.02.03P	isolate and remove defective renewable energy system components	defective components are isolated and removed without damage to system or other components
B-13.02.04P	repair malfunctioning components	repaired components are operational according to manufacturers' specifications
B-13.02.05P	select replacement components	replacement components (OEM replacement when mandated) match the application
B-13.02.06P	install replacement components	components are installed with minimal disruptions and interruptions

B-13.02.07P	conduct tests of ***renewable energy generating systems*** after repair	***renewable energy generating system*** is tested according to job, commissioning documentation, AHJ, CEC and company and client specifications
B-13.02.08P	***lubricate, clean and adjust*** components	***renewable energy generating systems*** are restored according to manufacturers' specifications
B-13.02.09P	record tests in maintenance schedule	maintenance log is updated to reflect maintenance tasks performed
B-13.02.10P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-13.02.11P	remove and dispose of unserviceable ***renewable energy generating system*** equipment	unserviceable equipment is disposed of according to jurisdictional and federal legislation, with minimal impact to the environment

RANGE OF VARIABLES

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

field assessments include: sensory inspections, technical inspections

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

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-13.02.01L	demonstrate knowledge of ***renewable energy generating systems***, their applications and operation	identify types of ***renewable energy generating systems*** and describe their characteristics, applications and operation
		identify renewable energy system components and describe their characteristics, applications and operation
		identify renewable energy generating ***storage system components***
		interpret codes and regulations pertaining to ***renewable energy generating systems***
B-13.02.02L	demonstrate knowledge of procedures to maintain ***renewable energy generating systems***	describe the procedures used to maintain ***renewable energy generating systems*** and their components
		describe the procedures used to maintain renewable energy generating ***storage system components***

RANGE OF VARIABLES

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

storage system components include: pumped hydro, compressed air energy storage, batteries (various technologies)

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 750V) 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 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

Essential Skills Document Use, Thinking, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-14.01.01P	determine installation requirements for ***high voltage equipment***	requirements for ***high voltage equipment*** are determined based on manufacturers’ specifications, CEC requirements, calculated load, company and client requirements, site-specific conditions, supply authority, AHJ and drawings
B-14.01.02P	determine layout and location of ***high voltage equipment***	***high voltage equipment*** is laid out according to drawings, manufacturers’ specifications, company and client specifications, supply authority, CEC requirements and AHJ

B-14.01.03P	assemble ***high voltage equipment***	***high voltage equipment*** is assembled according to job requirements and manufacturers' specifications, company and client specifications, supply authority and CEC requirements
B-14.01.04P	install ***high voltage equipment***	***high voltage equipment*** is installed according to CEC and job requirements, AHJ, manufacturers' specifications and drawings
B-14.01.05P	interconnect ***high voltage equipment***	***high voltage equipment*** is interconnected using busbars and high voltage cabling systems depending on application
B-14.01.06P	bond ***non-current carrying metallic components***	***non-current carrying metallic components*** are bonded to ground according to the CEC
B-14.01.07P	install ground grid	ground grid is installed according to AHJ, CEC requirements and industry standards
B-14.01.08P	perform ground resistance test	ground resistance test is performed using ***testing equipment*** and documented
B-14.01.09P	perform ***commissioning tests***	***commissioning tests*** are conducted using required ***testing standards*** according to AHJ and CEC requirements
B-14.01.10P	install labelling and signage on ***high voltage equipment***	***high voltage equipment*** is labelled, and signage is evident according to company and client, AHJ, and site and CEC requirements
B-14.01.11P	remove and dispose of unserviceable ***high voltage equipment*** and components	unserviceable ***high voltage equipment*** and components are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-14.01.12P	update ***documentation***	changes to the installation of ***high voltage equipment*** are documented on ***documentation*** required by AHJ, and company and client specifications

RANGE OF VARIABLES

high voltage equipment includes: distribution equipment, contactors, motor starters, transformers, MCC, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs

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

testing equipment includes: ground loop impedance tester, megohmmeter, proximity tester, phasing sticks

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

testing standards include: manufacturer, Institute of Electrical and Electronics Engineers (IEEE), CSA, AHJ

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 ***high voltage equipment***, its applications and operation	interpret codes, drawings, specifications and regulations pertaining to ***high voltage equipment***
		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 the purpose of grounding grids in relation to step and touch voltages
		explain the function of ***high voltage equipment***
B-14.01.02L	demonstrate knowledge of the procedures used to install ***high voltage equipment***	describe the procedures used to install ***high voltage equipment***
		describe the procedures used to size and install ground grid and grounding conductors
		describe the procedures used to terminate and splice high voltage conductors
		identify sources of information and ***documentation*** for installation of ***high voltage equipment***
		explain ***hazards*** associated with high voltage systems
		explain safety procedures to access high voltage environment
		describe procedure to isolate faults by de-energizing the source of energy

B-14.01.03L	demonstrate knowledge of testing procedures	identify testing procedures
		describe the procedures used to perform ground resistance testing and ***commissioning testing*** of ***high voltage equipment***

RANGE OF VARIABLES

high voltage equipment includes: distribution equipment, contactors, motor starters, transformers, MCC, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs

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, ultra-sonic detectors, thermographic imaging device

B-14.02 Maintains high voltage systems

Essential Skills	Thinking, Writing, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-14.02.01P	obtain description of trouble from user	malfunction issues and information are collected and documented
B-14.02.02P	conduct ***field assessment***	***field assessments*** are conducted using the ***diagnostic and test equipment*** according to drawings and manufacturers' specifications, company and client specifications and industry standards
B-14.02.03P	assess the risks associated with working around ***hazardous insulating mediums***	precautions are taken to lower exposure to ***hazardous insulating mediums***
B-14.02.04P	determine source of malfunction based on ***field assessment***	source of malfunction is identified
B-14.02.05P	determine course of action	course of action for the type of malfunction is identified according to availability of replacement parts
B-14.02.06P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected according to availability

B-14.02.07P	install replacement components	equivalent replacement components are installed according to as-built or manufacturers' specifications and commissioning documentation with minimal disruptions
B-14.02.08P	repair malfunctioning components	repaired components are verified to be operational according to manufacturers' specifications and commissioning documentation
B-14.02.09P	determine maintenance requirements	maintenance requirements are identified by consequence of failure, commissioning documentation and manufacturers' specifications
B-14.02.10P	create maintenance schedule	maintenance schedule is created by considering maintenance requirements and documentation and manufacturers' specifications
B-14.02.11P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-14.02.12P	isolate components	components are isolated in order to allow for testing procedures
B-14.02.13P	install and remove ***temporary protective grounds***	***temporary protective grounds*** are installed, tested and removed according to drawings and procedures
B-14.02.14P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and test results are documented
B-14.02.15P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-14.02.16P	update maintenance log and ***documentation***	maintenance log and ***documentation*** is updated to reflect maintenance tasks performed

RANGE OF VARIABLES

field assessments include: sensory inspections, technical inspections

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

hazardous insulating mediums include: $SF_{6,}$ PCB

temporary protective grounds include: clamps and straps, conductors

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-14.02.01L	demonstrate knowledge of the procedures used to maintain ***high voltage equipment***	describe the procedures used to maintain ***high voltage equipment*** and their ***components***
		interpret ***documentation*** related to high voltage equipment
B-14.02.02L	demonstrate knowledge of the methods used to maintain ***high voltage cables***	describe the procedures used to maintain ***high voltage cables*** and their ***components***
		explain ***hazards*** associated with high voltage systems
		explain safety procedures to access high voltage environment
		describe procedure to isolate faults by de-energizing the source of energy
B-14.02.03L	demonstrate knowledge of methods used to install and remove ***temporary protective grounds***	describe methods used to install ***temporary protective grounds***
		describe methods used to remove ***temporary protective grounds***

RANGE OF VARIABLES

high voltage equipment includes: distribution equipment, contactors, motor starters, transformers, MCC, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs

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

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

temporary protective grounds include: ground clamps and straps, conductors

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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Thinking, Numeracy, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-15.01.01P	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-15.01.02P	calculate conductor requirements	conductor type and size are selected according to CEC requirements
B-15.01.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to CEC requirements
B-15.01.04P	install overcurrent devices	overcurrent devices are installed so that transformer is protected
B-15.01.05P	remove existing ***extra-low voltage transformer*** prior to upgrade	***extra-low voltage transformers*** are removed with minimal impact to the surrounding equipment and interruption to operation
B-15.01.06P	position and mount ***extra-low voltage transformer***	***extra-low voltage transformer*** is placed and mounted according to the drawings and CEC requirements
B-15.01.07P	connect transformer terminations	transformer terminations are connected according to the drawings and CEC requirements
B-15.01.08P	check ***extra-low voltage transformer*** after installation	***extra-low voltage transformer*** is operational according to the application requirements

B-15.01.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements
B-15.01.10P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

extra-low voltage transformers include: Class 1 and Class 2 circuits, control transformers

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

KNOWLEDGE		
	Learning Outcomes	**Learning Objectives**
B-15.01.01L	demonstrate knowledge of ***extra-low voltage transformers***, their applications and operation	explain the operating principles of ***extra-low voltage transformers***
		identify code requirements pertaining to ***extra-low voltage transformers***
		interpret information contained on ***extra-low voltage transformer*** nameplates
		identify types of ***extra-low voltage transformers*** and describe their characteristics and applications
		identify ***extra-low voltage transformer components*** and describe their characteristics and applications
B-15.01.02L	demonstrate knowledge of procedures used to install ***extra-low voltage transformers***	describe the procedures used to install ***extra-low voltage transformers***

RANGE OF VARIABLES

extra-low voltage transformers include: Class 1 and Class 2 circuits, control transformers

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

B-15.02 Maintains extra-low voltage transformers

Essential Skills	Oral Communication, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.02.01P	obtain description of trouble of ***extra-low voltage transformers***	required information about equipment malfunction is gathered from end user
B-15.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
B-15.02.03P	identify and remove defective ***extra-low voltage transformers***	defective ***extra-low voltage transformers*** are removed without damage to system or other components
B-15.02.04P	select and install replacement ***extra-low voltage transformers***	replacement ***extra-low voltage transformer*** matches the application and is installed with minimal disruptions and interruptions and according to CEC requirements
B-15.02.05P	test ***extra-low voltage transformers***	***extra-low voltage transformer*** is operational according to application, manufacturers' specifications and CEC requirements
B-15.02.06P	***clean extra-low voltage transformers*** components	***extra-low voltage transformer*** components are restored according to manufacturers' specifications
B-15.02.07P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation***
B-15.02.08P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

extra-low voltage transformers include: Class 1 and Class 2 circuits, control transformers

field assessments include: sensory inspections, technical inspections

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

cleaning procedures include: cleaning filters, removing contaminants

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
B-15.02.01L	demonstrate knowledge of ***extra-low voltage transformers***, their applications and procedures for use	describe the characteristics and applications of ***extra-low voltage transformers***
		identify ***extra-low voltage transformer components*** and describe their characteristics
		interpret codes and regulations pertaining to ***extra-low voltage transformers***
		interpret information pertaining to ***extra-low voltage transformers*** found on drawings and specifications
		explain the operating principles of ***extra-low voltage transformers***
		interpret information contained on ***extra-low voltage transformers*** nameplates
B-15.02.02L	demonstrate knowledge of procedures used to maintain ***extra-low voltage transformers***	describe the procedures used to maintain ***extra-low voltage transformers*** and their ***components***

RANGE OF VARIABLES

extra-low voltage transformers include: Class 1 and Class 2 circuits, control transformers

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

B-15.03 Installs low voltage single-phase transformers

Essential Skills	Numeracy, Thinking, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
B-15.03.01P	determine type of ***low voltage single-phase transformer*** required and its rating	type of ***low voltage single-phase transformer*** meets criteria for operation
B-15.03.02P	calculate conductor requirements	conductor type and size are selected according to calculations and 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	install overcurrent devices	overcurrent devices are installed according to manufacturers' specifications and CEC requirements
B-15.03.05P	remove existing ***low voltage single-phase transformer*** prior to upgrade	***low voltage single-phase transformer*** is removed with minimal impact to the surrounding equipment and interruption to operation
B-15.03.06P	position and mount ***low voltage single-phase transformer***	***low voltage single-phase transformer*** is placed and mounted according to the application, company and client specifications, CEC requirements and AHJ
B-15.03.07P	connect ***low voltage single-phase transformers***	***low voltage single-phase transformers*** are connected according to CEC and ***system requirements***
B-15.03.08P	select and change tap settings of ***low voltage single-phase transformers***	output voltage meets application requirements
B-15.03.09P	ground and bond ***low voltage single-phase transformer***	***low voltage single-phase transformer*** is grounded and bonded to meet CEC requirements
B-15.03.10P	conduct ***tests*** of ***low voltage single-phase transformer*** after installation and document results	***low voltage single-phase transformer*** is functional and connected according to the application, CEC requirements and manufacturers' specifications
B-15.03.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation***
B-15.03.12P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

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

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

tests include: insulation test, voltage test, polarity test

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 ***low voltage single-phase transformers***, their applications and operation	explain the operating principles of ***low voltage single-phase transformers***
		interpret codes and regulations pertaining to ***low voltage single-phase transformers***
		identify types of ***low voltage single-phase transformers*** and describe their characteristics, applications and connections
		identify ***low voltage single-phase transformer components*** and describe their characteristics and applications
		interpret information contained on ***low voltage single-phase transformer*** nameplates
		explain ***low voltage single-phase transformer*** polarity and terminal markings
		identify the considerations and requirements for selecting ***low voltage single-phase transformers***
B-15.03.02L	demonstrate knowledge of procedures used to install ***low voltage single-phase transformers***	describe the procedures used to install ***low voltage single-phase transformers***
		describe the procedures used to install ***low voltage single-phase transformers*** in parallel

RANGE OF VARIABLES

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

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

B-15.04 Maintains low voltage single-phase transformers

Essential Skills Numeracy, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.04.01P	obtain description of trouble of ***low voltage single-phase transformers***	required information about equipment malfunction is gathered from end user
B-15.04.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
B-15.04.03P	select and install replacement ***low voltage single-phase transformer components***	equivalent replacement ***low voltage single-phase transformer components*** match the application and are installed with minimal disruptions and interruptions and according to CEC requirements, manufacturers' specifications, and company and client specifications
B-15.04.04P	repair malfunctioning ***low voltage single-phase transformer components***	repaired components are operational
B-15.04.05P	determine maintenance requirements	maintenance requirements are completed according to maintenance schedule and manufacturers' specifications
B-15.04.06P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and manufacturers' specifications and test results are documented
B-15.04.07P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.04.08P	***clean and adjust*** components	transformers are restored according to manufacturers' specifications
B-15.04.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation*** according to CEC

B-15.04.10P	remove and dispose of unserviceable components	unserviceable components are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-15.04.11P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

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

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 and automatic tap changers

cleaning and adjustment includes: re-torquing of terminations, cleaning/replacing filters, cleaning cooling fans, checking door seals

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 ***low voltage single-phase transformers***, their applications and operation	explain the operating principles of ***low voltage single-phase transformers***
		identify types of ***low voltage single-phase transformers*** and describe their characteristics and applications
		interpret codes and regulations pertaining to ***low voltage single-phase transformers***
		identify ***low voltage single-phase transformer components*** and describe their characteristics and applications
		interpret information contained on ***low voltage single-phase transformer*** nameplates
		explain transformer polarity and terminal markings
		identify the considerations and requirements for selecting ***low voltage single-phase transformers***
B-15.04.02L	demonstrate knowledge of procedures used to maintain ***low voltage single-phase transformers***	describe the procedures used to maintain ***low voltage single-phase transformers***

RANGE OF VARIABLES

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

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

B-15.05 Installs low voltage three-phase transformers

Essential Skills Numeracy, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.05.01P	determine type of ***low voltage three-phase transformer*** required and its rating	type of ***low voltage three-phase transformer*** meets criteria for operation
B-15.05.02P	calculate conductor requirements	conductor type and size are selected according to calculations and 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	install overcurrent devices	overcurrent devices are installed according to manufacturers' specifications and CEC requirements
B-15.05.05P	remove existing ***low voltage three-phase transformer*** prior to upgrade	***low voltage three-phase transformer*** is removed with minimal impact to surrounding equipment and interruption to operation
B-15.05.06P	position and mount ***low voltage three-phase transformer***	***low voltage three-phase transformer*** is placed and mounted according to the application, company and client specifications, CEC requirements and AHJ
B-15.05.07P	connect ***low voltage three-phase transformers***	***low voltage three-phase transformers*** are connected according to CEC and ***system requirements***
B-15.05.08P	select and change tap settings of ***low voltage three-phase transformers***	output voltage meets application requirements
B-15.05.09P	ground and bond ***low voltage three-phase transformers***	transformer is grounded and bonded to meet CEC requirements

B-15.05.10P	conduct ***tests*** of ***low voltage three-phase transformer*** after installation and document results	***low voltage three-phase transformer*** is functional and connected according to the application, CEC requirements and manufacturers' specifications
B-15.05.11P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.05.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation***
B-15.05.13P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

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

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

tests include: insulation test, voltage test, polarity test, turn ratio 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 ***low voltage three-phase transformers***, their applications and operation	explain the operating principles of ***low voltage three-phase transformers***
		interpret codes and regulations pertaining to ***low voltage three-phase transformers***
		identify types of ***low voltage three-phase transformers*** and describe their characteristics and applications
		identify ***winding configurations*** for ***low voltage three-phase transformers***
		identify ***low voltage three-phase transformer components*** and describe their characteristics and applications
		interpret information contained on ***low voltage three-phase transformer*** nameplates
		explain ***low voltage three-phase transformer*** polarity and terminal markings

		identify the considerations and requirements for selecting ***low voltage three-phase transformers***
B-15.05.02L	demonstrate knowledge of procedures used to install ***low voltage three-phase transformers***	describe the procedures used to install ***low voltage three-phase transformers***
		describe the procedures used to install ***low voltage three-phase transformers*** in parallel
		describe the procedures used to install ***low voltage three-phase transformers*** using various ***winding configurations***

RANGE OF VARIABLES

low voltage three-phase transformers include: dry-type, 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

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

B-15.06 Maintains low voltage three-phase transformers

Essential Skills	Oral Communication, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.06.01P	obtain description of trouble of ***low voltage three-phase transformers***	required information about equipment malfunction is gathered from end user
B-15.06.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
B-15.06.03P	select and install replacement ***low voltage three-phase transformer components***	equivalent replacement ***low voltage three-phase transformer components*** match the application and are installed with minimal disruptions and interruptions and according to CEC requirements, manufacturers' specifications, and company and client specifications
B-15.06.04P	repair malfunctioning ***low voltage three-phase transformer components***	repaired ***low voltage three-phase transformer components*** are operational

B-15.06.05P	determine maintenance requirements	maintenance requirements are completed according to maintenance schedule and manufacturers' specifications
B-15.06.06P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and manufacturers' specifications and test results are documented
B-15.06.07P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.06.08P	***clean and adjust*** components	transformers are restored according to manufacturers' specifications
B-15.06.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation*** according to CEC
B-15.06.10P	remove and dispose of unserviceable components	unserviceable components are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-15.06.11P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

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

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

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

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

cleaning and adjustment procedures include: re-torquing of terminations, cleaning/replacing filters, cleaning cooling fans, checking door seals

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 ***low voltage three-phase transformers***, their applications and operation	explain the operating principles of ***low voltage three-phase transformers***
		identify types of ***low voltage three-phase transformers*** and describe their characteristics and applications
		identify ***winding configurations*** for ***low voltage three-phase transformers***

		interpret codes and regulations pertaining to ***low voltage three-phase transformers***
		identify ***low voltage three-phase transformer components*** and describe their characteristics and applications
		interpret information contained on ***low voltage three-phase transformer*** nameplates
		explain ***low voltage three-phase transformer*** polarity and terminal markings
		identify the considerations and requirements for selecting ***low voltage three-phase transformers***
B-15.06.02L	demonstrate knowledge of procedures used to maintain ***low voltage three-phase transformers***	describe the procedures used to maintain ***low voltage three-phase transformers***

RANGE OF VARIABLES

low voltage three-phase transformers include: dry-type, 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

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

B-15.07 Installs high voltage transformers

Essential Skills	Numeracy, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.07.01P	determine type of ***high voltage transformer*** required and rating	type of ***high voltage transformer*** meets criteria for operation
B-15.07.02P	calculate conductor requirements	conductor type and size are selected according to calculations, drawings, AHJ and CEC requirements
B-15.07.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to calculations, manufacturers' specifications and CEC requirements

B-15.07.04P	install overcurrent devices	overcurrent devices are installed according to manufacturers' specifications and CEC requirements
B-15.07.05P	remove existing ***high voltage transformer*** prior to upgrade	***high voltage transformer*** is removed with minimal impact to surrounding equipment and interruption to operation
B-15.07.06P	position and mount ***high voltage transformer***	***high voltage transformer*** is placed and mounted according to the application, CEC requirements and AHJ
B-15.07.07P	connect ***high voltage transformers***	***high voltage transformers*** are connected according to CEC and ***system requirements***
B-15.07.08P	select and change tap settings of ***high voltage transformer***	output voltage meets application requirements
B-15.07.09P	terminate high voltage conductors	high voltage conductors are terminated according to application and manufacturers' specifications and CEC
B-15.07.10P	ground and bond ***high voltage transformer***	***high voltage transformer*** is grounded and bonded to meet CEC requirements
B-15.07.11P	conduct ***tests*** of ***high voltage transformer*** after installation and document results	***high voltage transformer*** is functional and connected according to the application, drawings and manufacturers' specifications
B-15.07.12P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.07.13P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation***
B-15.07.14P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

high voltage transformers include: 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

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 ***high voltage transformers***, their applications and operation	explain the operating principles of ***high voltage transformers***
		identify terminology associated with ***high voltage transformers***
		interpret codes and regulations pertaining to ***high voltage transformers***
		identify types of ***high voltage transformers*** and describe their characteristics and applications
		identify ***winding configurations*** for ***high voltage transformers***
		identify ***high voltage transformer components*** and describe their characteristics and applications
		interpret information contained on ***high voltage transformer*** nameplates
		explain ***high voltage transformer*** polarity and terminal markings
		identify the considerations and requirements for selecting ***high voltage transformers***
B-15.07.02L	demonstrate knowledge of procedures used to install ***high voltage transformers***	describe the procedures used to install ***high voltage transformers***

RANGE OF VARIABLES

high voltage transformers include: liquid-filled, dry

winding configurations include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag

high voltage transformer components include: oil pumps, ventilation fans, casings and enclosures, core, primary and secondary windings, desiccant breather, bushings, on-line and off-line tap changers, oil temperature, pressure and level gauges, phase indicators

B-15.08 Maintains high voltage transformers

Essential Skills	Oral Communication, Working with Others, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
B-15.08.01P	obtain description of trouble of high voltage transformers	required information about equipment malfunction is gathered from end user
B-15.08.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
B-15.08.03P	inspect high voltage cables	high voltage cables are inspected for irregularities
B-15.08.04P	select and install replacement high voltage transformer components	equivalent replacement high voltage transformer components match the application and are installed with minimal disruptions and interruptions and according to CEC requirements and manufacturers' specifications
B-15.08.05P	repair malfunctioning high voltage transformer components	repaired high voltage transformer components are operational
B-15.08.06P	determine maintenance requirements	maintenance requirements are completed according to maintenance schedule and manufacturers' specifications
B-15.08.07P	conduct tests using ***diagnostic and test equipment***	tests are conducted according to established maintenance schedule and manufacturers' specifications and test results are documented
B-15.08.08P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
B-15.08.09P	***clean and adjust*** components	high voltage transformers are restored to optimal conditions according to manufacturers' specifications
B-15.08.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and ***documentation***

B-15.08.11P	remove and dispose of unserviceable components	unserviceable components are disposed of according to jurisdictional and federal legislation, and waste disposal requirements
B-15.08.12P	update ***documentation***	***documentation*** reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

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, proximity tester

cleaning and adjustment procedures include: re-torquing of terminations, cleaning/replacing filters, cleaning cooling fans, checking door seals, cleaning the insulators

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 ***high voltage transformers***, their applications and operation	explain the operating principles of ***high voltage transformers***
		identify types of ***high voltage transformers*** and describe their characteristics and applications
		identify ***winding configurations*** for ***high voltage transformers***
		identify high voltage conductors and describe their characteristics and application
		interpret codes and regulations pertaining to ***high voltage transformers***
		identify ***high voltage transformers components*** and describe their characteristics and applications
		interpret information contained on ***high voltage transformers*** nameplates
		explain ***high voltage transformer*** polarity and terminal markings
		identify the considerations and requirements for selecting ***high voltage transformers***
B-15.08.02L	demonstrate knowledge of procedures used to maintain ***high voltage transformers***	describe the procedures used to maintain ***high voltage transformers***

RANGE OF VARIABLES

high voltage transformers are: liquid-filled, dry

winding configurations include: wye-wye, wye-delta, delta-wye, open-delta, delta-delta, zig-zag

high voltage transformer components include: oil pumps, ventilation fans, casings and enclosures, core, primary and secondary windings, bushings, on-line and off-line tap changers, dielectric liquid, indicators (pressure gauges, level gauges, temperature gauges), cooling fins, conservator, desiccant breather

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. 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 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

Essential Skills	Thinking, Numeracy, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-16.01.01P	determine ***installation requirements*** and select conductors and cables, and ***components***	size, type and number of conductors, cables and ***components*** are selected, identified and colour-coded according to CEC requirements, AHJ, drawings and specifications
C-16.01.02P	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-16.01.03P	install conductors, cables and ***components***	conductors, cables and ***components*** are installed according to CEC requirements, drawings, specifications and AHJ

C-16.01.04P	assemble ***components***	***components*** are assembled and installed according to CEC requirements, drawings, specifications and AHJ
C-16.01.05P	prepare conductors and cables for termination	conductors and cables are cleaned and prepared for termination according to CEC requirements, drawings, specifications and AHJ
C-16.01.06P	terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings, specifications and AHJ
C-16.01.07P	complete documentation to reflect changes to new and updated installations	all changes are documented in the documentation
C-16.01.08P	determine requirements for removal of existing conductors and cables and ***components***	removal requirements are determined according to company and client requirements and considering the impact the removal will have on the facility
C-16.01.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation meets requirements and documentation according to manufacturers' and company specifications
C-16.01.10P	remove conductors, cables, and ***components*** and update documentation	conductors, cables, and ***components*** are removed according to electrical specifications and AHJ and remaining installations are supported and terminated and left in a safe and secure state according to CEC requirements

RANGE OF VARIABLES

installation requirements include: purpose of the 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, divisions, categories and zones

components include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds, non-ferrous and/or non-conductive plates, and connectors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-16.01.01L	demonstrate knowledge of types of conductors, cables and their associated ***components***	identify terminology associated with conductors, cables and their associated ***components***
		identify types of conductors, cables and ***components*** and describe their characteristics and applications
		interpret codes, standards and regulations pertaining to conductors and cables
		interpret information pertaining to conductors and cables found on drawings and specifications

C-16.01.02L	demonstrate knowledge of procedures used to remove and install conductors, cables and their associated ***components***	identify the considerations and requirements for selecting conductors, cables and their associated ***components***
		describe the procedures used to remove conductors, cables and their associated ***components***
		describe the procedures used to prepare and install conductors, cables and their associated ***components***
		describe the procedures used to terminate conductors and cables
		identify the considerations and requirements for removal of conductors, cables and their associated ***components***

RANGE OF VARIABLES

components include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compound

C-16.02 Maintains conductors and cables

Essential Skills Digital Technology, Reading, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-16.02.01P	obtain description of fault from user	fault issues and information are collected and documented
C-16.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** and document results	***diagnostic and test equipment*** is used to determine state of conductors and cables, and test results are documented
C-16.02.03P	troubleshoot to determine type and location of fault based on ***field assessment***	type and location of fault is identified
C-16.02.04P	repair or replace faulty ***component***	faulty ***component*** is repaired or replaced and tested, and system is returned to original condition

C-16.02.05P	label repaired conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure repair meets requirements and documentation and according to manufacturers' and company specifications
C-16.02.06P	re-torque terminations and test conductors for excessive heating	terminations are re-torqued according to manufacturers' specifications and documentation of torquing and test results is completed

RANGE OF VARIABLES

field assessments include: sensory and technical inspections, hi-pot test

diagnostic and test equipment includes: megohmeters, multimeters, thermographic imaging devices, cable locators, hi-pot testers

components include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-16.02.01L	demonstrate knowledge of the different types of conductors, cables and their associated components	identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause faults in specific types of conductors, cables and their associated components
		interpret information pertaining to conductors and cables found on manufacturers' specifications and previous records
		interpret codes, standards and regulations pertaining to conductors and cables
C-16.02.02L	demonstrate knowledge of the procedures to maintain conductors, cables and their associated components	identify the ***considerations*** when maintaining conductors, cables and their associated components
		describe the ***procedures*** to maintain conductors, cables and their associated components

RANGE OF VARIABLES

considerations include: integrity of the insulation, tightness of the 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

Essential Skills	Numeracy, Thinking, Working with Others

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-16.03.01P	determine ***installation requirements*** and select conduit, tubing and fittings	size and ***type*** of conduit, tubing and fittings are selected according to CEC requirements, AHJ, drawings and specifications
C-16.03.02P	determine routing of conduit and tubing	routing of the conduit and tubing is practical for the application and takes into consideration other trades and according to CEC requirements, AHJ, drawings and specifications
C-16.03.03P	measure, cut, thread and bend conduit and tubing	conduit and tubing are measured, cut, threaded and bent to meet the requirements of the routing according to CEC requirements, AHJ, drawings and specifications
C-16.03.04P	assemble, position, mount and support conduit, tubing and fittings	conduit, tubing and fittings are assembled, positioned, mounted and supported without damage to meet the requirements of the application and, according to CEC requirements, AHJ, drawings and specifications
C-16.03.05P	determine requirements for removal of existing conduit, tubing and fittings	removal requirements are determined according to company and client requirements and considering the impact removal will have on the facility
C-16.03.06P	remove conduit, tubing and fittings and update documentation	conduit, tubing and fittings are removed and remaining installations are supported and terminated according to CEC requirements, AHJ, drawings and specifications

RANGE OF VARIABLES

installation requirements include: purpose of the conduit, tubing and fitting, tools and equipment required for installation, installation environment in locations such as hazardous, wet, underground, outdoor, classes, divisions, categories and zones, combustible and non-combustible installations

types include: rigid metal, rigid Poly Vinyl Chloride (PVC), electrical metallic tubing (EMT), liquid-tight flex, coated rigid, non-metallic flex

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-16.03.01L	demonstrate knowledge of types of conduit, tubing and ***fittings, their components*** and applications	identify types of conduit, tubing, ***fittings and components*** and describe their characteristics, applications and limitations
		identify ***tools and equipment*** related to conduit, tubing and fittings and describe their applications and procedures for use
		interpret information pertaining to conduit, tubing and fittings found on drawings and specifications
		interpret codes and regulations pertaining to conduit, tubing, ***fittings and components***
C-16.03.02L	demonstrate knowledge of procedures to remove and install conduit, tubing, ***fittings and components***	describe the procedures used to cut, thread (if applicable) and bend conduit and tubing
		describe the procedures used to install and support conduit and tubing, ***fittings and components***
		identify the considerations and requirements for removal of conduit, tubing and ***fittings and components***
		describe the procedures used for the removal of conduit and tubing, ***fittings and components***
		interpret codes and regulations pertaining to conduit, tubing, ***fittings and components***
		identify considerations of other trades within the same project

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, heat guns, pipe benders, pipe threading machines, power pipe benders, equipment for specialized conduit systems

C-16.04 Installs raceways

Essential Skills	Numeracy, Thinking, Working with Others

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-16.04.01P	determine ***installation requirements*** and select raceways	size and type of ***raceway*** are selected according to CEC requirements, AHJ, drawings and specifications
C-16.04.02P	determine routing of ***raceway***	routing of the ***raceway*** is practical for the application and takes into consideration other trades and CEC requirements, AHJ, drawings and specifications
C-16.04.03P	measure and cut ***raceways***, and select fittings	***raceways*** are measured and cut and fittings are selected to meet the requirements of the routing according to CEC requirements, AHJ, drawings and specifications
C-16.04.04P	assemble ***raceways*** and fittings into position and mount and support ***raceways***	***raceways*** and fittings are assembled into position and ***raceways*** are mounted and supported without damage to meet the requirements of the application and according to CEC requirements, AHJ, drawings and specifications
C-16.04.05P	determine requirements for removal of existing ***raceways*** if applicable when performing an upgrade	removal requirements are determined according to company and client requirements and considering the impact removal will have on the facility
C-16.04.06P	remove ***raceways*** and their ***components*** and update documentation	***raceways*** and their ***components*** are removed according to electrical specifications and remaining installations are supported and terminated according to CEC requirements, AHJ, drawings and specifications

RANGE OF VARIABLES

installation requirements include: purpose of the raceway, equipment required for installation, installation environment in locations such as hazardous, wet, outdoor, classes, divisions, categories and zones

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-16.04.01L	demonstrate knowledge of types of ***raceways*** and their ***components***	identify types of ***raceways*** and ***components***, and describe their characteristics, applications and limitations
		interpret codes, standards and regulations pertaining to ***raceways***
		interpret information pertaining to ***raceways*** found on drawings and specifications
C-16.04.02L	demonstrate knowledge of procedures used to remove and install and support ***raceways***	identify the considerations and requirements for selecting ***raceways*** and their ***components***
		describe the procedures used to install and support ***raceways*** and their ***components***
		identify the considerations and requirements for removal of ***raceways*** and their ***components***
		describe the procedures used to remove ***raceways*** and their ***components***
		identify considerations of other trades within the same project

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

C-16.05 Installs boxes and enclosures

Essential Skills Thinking, Numeracy, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-16.05.01P	determine ***installation requirements*** and select boxes and ***enclosures***	size and type of boxes and ***enclosures*** are selected according to CEC requirements, AHJ, drawings and specifications
C-16.05.02P	determine installation location for boxes and ***enclosures***	location for the box and ***enclosures*** is practical for the application and takes into consideration other trades according to CEC requirements, AHJ, drawings and specifications
C-16.05.03P	position and mount boxes and ***enclosures***	boxes and ***enclosures*** are positioned and mounted without damage to meet the requirements of the application and according to CEC requirements, AHJ, drawings and specifications
C-16.05.04P	determine requirements for removal of existing boxes and ***enclosures***	removal requirements are determined according to company and client requirements and considering the impact removal will have on the facility
C-16.05.05P	remove boxes and ***enclosures*** and update documentation	boxes and ***enclosures*** are removed and remaining installations are supported and terminated according to CEC requirements, AHJ, drawings and specifications

RANGE OF VARIABLES

installation requirements include: purpose of the box or enclosure, equipment required for installation, installation environment in locations such as hazardous, wet, indoor/outdoor, classes, divisions, categories and zones

enclosures do not include: enclosure types for specific electrical equipment such as rotating equipment, transformers, panel boards, motor starters and other fixed equipment

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-16.05.01L	demonstrate knowledge of boxes and ***enclosures***	identify types of boxes and ***enclosures*** and describe their characteristics, applications and limitations
		interpret codes, standards and regulations pertaining to boxes and ***enclosures***
		interpret information pertaining to boxes and ***enclosures*** found on drawings and specifications
C-16.05.02L	demonstrate knowledge of procedures used to remove, install and support boxes and ***enclosures***	identify the ***considerations*** and requirements for selecting boxes and ***enclosures***
		describe the procedures used to determine placement and to mount boxes and ***enclosures***
		identify the ***considerations*** and requirements for removal of boxes and ***enclosures***
		describe the procedures used to remove boxes and ***enclosures***
		identify ***considerations*** of other trades within the same project

RANGE OF VARIABLES

enclosures do not include: enclosure types for specific electrical equipment such as rotating equipment, transformers, panel boards, motor starters and other fixed equipment

considerations include: materials, volume, dimensions, positioning, environment, accessibility, size of raceway or cable entering the box or enclosure, CSA types, Ingress Protection (IP) types

C-16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures

Essential Skills	Reading, Document Use, Oral Communication

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-16.06.01P	conduct ***inspection*** of conduit, tubing, fittings, raceways, boxes, enclosures and associated ***components*** and document results	***inspection*** is completed and documented
C-16.06.02P	clean conduit, tubing, fittings, raceways, boxes, enclosures and associated ***components***	***components*** are cleaned according to housekeeping standards and AHJ requirements
C-16.06.03P	locate and determine type of fault based on ***inspection***	type and location of fault is identified
C-16.06.04P	repair or replace damaged conduit, tubing, fittings, raceways, boxes, enclosures and associated ***components***	damaged ***component*** is repaired or replaced according to CEC and AHJ requirements
C-16.06.05P	tighten or adjust loose ***components***	***components*** are tightened or adjusted according to CEC and AHJ requirements

RANGE OF VARIABLES

inspections include: visual (internal and external) and physical inspections
components include: supports, expansion joints, straps, connectors, couplings, screws, bolts

KNOWLEDGE

	Learning Outcomes	Learning Objectives
C-16.06.01L	demonstrate knowledge of the types of conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***	identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause damage in specific types of conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***
		interpret codes, standards and regulations pertaining to conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***
C-16.06.02L	demonstrate knowledge of the procedures to maintain conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***	identify the ***considerations*** when maintaining conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***

	describe the procedures to repair or replace conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***
	describe the procedures to tighten or adjust conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***
	describe the procedures to clean conduit, tubing, fittings, raceways, boxes and enclosures and their associated ***components***

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 end user. Branch circuitry components are installed in a manner which makes the power safe and convenient to use. 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 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

Essential Skills Numeracy, Thinking, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-17.01.01P	determine type of ***luminaire*** and ***installation requirements***	size and type of ***luminaire*** are selected for the application and according to drawings, specifications, and company, client and CEC requirements
C-17.01.02P	calculate branch circuit requirements	calculations are completed based on the voltage and amperage requirements and according to CEC requirements
C-17.01.03P	determine installation location for ***luminaire***	***luminaire*** locations are determined according to drawings, specifications, company and client requirements, codes and the design criteria for the luminaire
C-17.01.04P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and CEC requirements
C-17.01.05P	mount ***luminaire***	***luminaire*** is mounted and supported according to drawings, specifications, CEC requirements, other codes, and company and client requirements
C-17.01.06P	install branch circuit wiring	branch circuit wiring is installed and identified according to drawings, specifications and CEC requirements without damage to insulation and without stress

C-17.01.07P	terminate conductors	conductors and cables are terminated using connectors according to manufacturers' specifications and CEC requirements
C-17.01.08P	test for required operation	operation is confirmed by testing operation and lighting levels
C-17.01.09P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
C-17.01.10P	determine requirements for removal of ***luminaires***	removal requirements are determined according to company and client requirements and considering the impact removal will have on the facility
C-17.01.11P	remove existing ***luminaires***	***luminaires*** are removed and remaining installations are left in a safe condition according to CEC and AHJ requirements and company specifications
C-17.01.12P	update documentation	documentation is completed to reflect changes
C-17.01.13P	dispose of lamps and ballasts	lamps and ballasts are disposed of according to jurisdictional and federal legislation, and waste disposal requirements

RANGE OF VARIABLES

luminaires include: high intensity discharge (HID), light emitting diode (LED), incandescent, fluorescent, lighting standards

installation requirements include: purpose of the luminaire, equipment required for installation, lighting controls, seismic requirements, installation environment in locations such as hazardous, wet, indoor/outdoor, classes, divisions, categories and zones

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-17.01.01L	demonstrate knowledge of ***luminaires***, their applications and operation	identify types of ***luminaires*** and describe their applications and operation
		identify ***luminaires*** components and describe their characteristics and applications
		interpret codes, standards and regulations pertaining to ***luminaires***
		interpret information pertaining to ***luminaires*** found on drawings and specifications
C-17.01.02L	demonstrate knowledge of the procedures used to remove, install, dispose of and support ***luminaires***	identify the considerations and requirements for the removal of ***luminaires*** and their components

	identify the considerations and requirements for selecting ***luminaires*** and their components
	describe the procedures to remove ***luminaires*** and their components
	describe the procedures to retrofit ***luminaires*** and their components
	describe the procedures used to install and support ***luminaires*** and their components
	describe the procedures used to perform tests related to ***luminaires***
	describe the procedures for disposal of ***luminaires*** and their components

RANGE OF VARIABLES

luminaires include: HID, LED, incandescent, fluorescent, lighting standards

C-17.02 Maintains luminaires

Essential Skills Document Use, Thinking, Reading

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-17.02.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** based on user observation or complaint	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
C-17.02.02P	identify and remove defective components of branch circuitry and ***luminaires***	defective components are removed without damage to system or other components
C-17.02.03P	select replacement components	replacement components are selected to match the existing application
C-17.02.04P	install replacement components	components are installed with minimal disruptions and interruptions
C-17.02.05P	conduct tests of branch circuitry and ***luminaire*** after repair	branch circuitry and ***luminaire*** is functional and connected according to manufacturers' specifications and codes
C-17.02.06P	update documentation	documentation is completed to reflect changes

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, fluorescent light tester, lumen meters

luminaires include: HID, LED, incandescent, fluorescent, lighting standards

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-17.02.01L	demonstrate knowledge of branch circuitry and ***luminaire*** components	identify types of branch circuitry and components of the ***luminaires*** and describe their applications and operation
C-17.02.02L	demonstrate knowledge of the procedures used to maintain branch circuitry and ***luminaire*** components	describe the procedures used to maintain branch circuitry and ***luminaire*** components

RANGE OF VARIABLES

luminaires include: HID, LED, incandescent, fluorescent, lighting standards

C-17.03 Installs wiring devices

Essential Skills Thinking, Numeracy, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-17.03.01P	determine type of ***wiring devices*** required and the associated ***installation requirements***	size and type of ***wiring devices*** are selected for the application and according to drawings, specifications, CEC requirements and company requirements
C-17.03.02P	determine installation location for ***wiring devices***	***wiring devices*** locations are determined considering drawings and specifications and CEC, company and client requirements
C-17.03.03P	select ***wiring device***	***wiring device*** is selected according to drawings and specifications, and CEC requirements
C-17.03.04P	install wiring	wiring is installed and identified according to drawings, specifications and CEC requirements without damage to insulation and without stress

C-17.03.05P	mount ***wiring devices***	***wiring devices*** are mounted according to manufacturers' specifications and CEC requirements
C-17.03.06P	terminate conductors	conductors and cables are terminated using connectors according to manufacturers' specifications and CEC requirements
C-17.03.07P	test for required operation	operation is confirmed by testing the circuit for specified voltage and phasing
C-17.03.08P	select and install cover plate	cover plate is selected and installed to the industry standards and codes
C-17.03.09P	determine requirements for removal of ***wiring devices***	removal requirements are determined according to company and client requirements and considering the impact removal will have on the facility
C-17.03.10P	remove existing ***wiring devices***	***wiring devices*** are removed and remaining installations are left in a safe condition according to CEC and AHJ requirements
C-17.03.11P	update documentation	documentation is completed to reflect changes

RANGE OF VARIABLES

wiring devices include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles

installation requirements include: purpose of the wiring device, equipment required for installation, device controls, seismic requirements, installation environment in locations such as hazardous, wet, indoor/outdoor, classes, divisions, categories and zones

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-17.03.01L	demonstrate knowledge of ***wiring devices***, their applications and operation	identify types of ***wiring devices*** and describe their applications and operation
		interpret codes, standards and regulations pertaining to ***wiring devices***
		interpret information pertaining to ***wiring devices*** found on drawings and specifications
C-17.03.02L	demonstrate knowledge of the procedures used to remove and install ***wiring devices***	identify the considerations and requirements for the removal of ***wiring devices***
		identify the considerations and requirements for selecting ***wiring devices***
		describe the procedures to install and remove ***wiring devices***

RANGE OF VARIABLES

wiring devices include: switches, timers, sensors, relays, controllers, disconnects, power outlets, receptacles

C-17.04 Maintains wiring devices

Essential Skills Document Use, Thinking, Reading

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-17.04.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** based on user complaints	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
C-17.04.02P	identify and remove defective components of branch circuitry and ***wiring devices***	defective component is removed without damage to system or other components
C-17.04.03P	select replacement components	replacement components match the existing application
C-17.04.04P	install replacement components	components are installed with minimal disruptions and interruptions
C-17.04.05P	conduct tests of branch circuitry and ***wiring devices*** after repair	branch circuitry and ***wiring devices*** are functional and connected according to manufacturers' specifications and CEC requirements
C-17.04.06P	update documentation	documentation is completed to reflect changes

RANGE OF VARIABLES

field assessments include: sensory and 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 wiring device components	identify types of branch circuitry and wiring device components and describe their applications and operation
C-17.04.02L	demonstrate knowledge of the procedures used to maintain branch circuitry and wiring device components	describe the procedures used to maintain branch circuitry and wiring device components

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 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

Essential Skills	Reading, Working with Others, Oral Communication

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-18.01.01P	determine connected load requirements for the ***HVAC systems and associated equipment***	connected load requirements are determined by interpreting nameplate ratings, drawings, specifications, CEC requirements and AHJ
C-18.01.02P	select feeder and/or branch circuit wiring, disconnect means and overcurrent protection for the ***HVAC systems and associated equipment***	feeders and/or branch circuit wiring, disconnect means and overcurrent protection are selected according to drawings, specifications, CEC requirements and AHJ

C-18.01.03P	install feeder and/or branch circuit wiring, disconnect means and overcurrent protection for the ***HVAC systems and associated equipment***	feeders and/or branch circuit wiring conductors are installed without damage to insulation, without stress and the circuit conductors are identified, selected and installed according to drawings, specifications, CEC requirements and AHJ
C-18.01.04P	terminate conductors	cables and conductors are terminated and torqued according to drawings, manufacturers' specifications and CEC requirements
C-18.01.05P	test operation	operation is verified by testing the circuit for specified voltage, amperage and rotation according to AHJ
C-18.01.06P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

HVAC systems and associated equipment includes: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-18.01.01L	demonstrate knowledge of ***HVAC systems***, their applications and operation	identify terminology associated with ***HVAC systems***, controls and ***associated equipment***
		identify types of ***HVAC systems*** and describe their characteristics and applications
		interpret information pertaining to ***HVAC systems*** found on drawings, specifications and nameplates
		interpret codes, standards and regulations pertaining to the electrical components of ***HVAC systems***
C-18.01.02L	demonstrate knowledge of the procedures used to connect ***HVAC systems and associated equipment***	identify considerations and requirements for connecting ***HVAC systems and associated equipment***
		describe the procedures used to connect ***HVAC systems and associated equipment***

RANGE OF VARIABLES

HVAC systems and associated equipment includes: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

C-18.02 Installs HVAC controls

Essential Skills	Reading, Working with Others, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-18.02.01P	determine circuitry and load requirements	calculations are completed based on the voltage and amperage requirements, specifications and CEC requirements
C-18.02.02P	install control circuit wiring	control circuit wiring conductors are installed without damage to insulation, without stress and the circuit conductors are identified, selected and installed according to drawings, specifications, CEC requirements and AHJ
C-18.02.03P	assemble and install ***control components***	***control components*** are assembled and installed according to CEC requirements and manufacturers' specifications
C-18.02.04P	terminate conductors	cables and conductors are terminated and torqued according to drawings, manufacturers' specifications and CEC requirements
C-18.02.05P	program and test HVAC controls	program is verified by operation of the HVAC controls according to specifications, company and client requirements, AHJ and commissioning procedures
C-18.02.06P	document test results	test results are documented
C-18.02.07P	determine requirements for isolation and removal of existing HVAC controls when performing an upgrade	removal requirements are determined according to environmental regulations, company and client requirements and considering the impact removal will have on the facility
C-18.02.08P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

control components include: time clocks, relays, thermostats, sensors, actuators, electrical interlocks, multiple function controllers, VFDs, discrete and analog devices

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-18.02.01L	demonstrate knowledge of types of HVAC ***control components***, their applications and operation	identify types of HVAC ***control components*** and describe their characteristics and applications
		interpret information pertaining to HVAC ***control components*** found on drawings and specifications
		interpret codes and regulations pertaining to HVAC ***control components***
C-18.02.02L	demonstrate knowledge of the procedures used to install or replace, connect and test HVAC ***control components***	identify the considerations and requirements for removal of HVAC ***control components***
		identify considerations and requirements for selecting HVAC ***control components***
		describe the procedures used to isolate and remove HVAC ***control components***
		describe the procedures used to install HVAC ***control components***
		describe the procedures used to connect HVAC ***control components***
		describe the procedures used to test HVAC ***control components***

RANGE OF VARIABLES

control components include: time clocks, relays, sensors, thermostats, actuators, electrical interlocks, multiple function controllers, variable frequency drive (VFD), discrete and analog devices

C-18.03 Maintains HVAC electrical components

Essential Skills	Reading, Working with Others, Oral Communication

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-18.03.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** to verify operation of the ***electrical components***	***electrical components*** are verified according to manufacturers' specifications and operational requirements
C-18.03.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results

C-18.03.03P	identify and remove defective ***electrical components***	defective ***electrical component*** is removed without damage to system or other components
C-18.03.04P	repair malfunctioning ***electrical components***	repaired ***electrical components*** and equipment are operational
C-18.03.05P	select replacement ***electrical components***	replacement ***electrical components*** are selected according to manufacturers' specifications and to match the application
C-18.03.06P	install replacement ***electrical components*** and reprogram	***electrical components*** are installed with minimal disruptions and interruptions and are reprogrammed to the parameters prior to replacement
C-18.03.07P	conduct tests of ***electrical components*** after repair	***electrical components*** are connected and function according to manufacturers', company and client specifications and the system operation is verified
C-18.03.08P	document tests in maintenance schedule	operational problems are identified in maintenance schedule data

RANGE OF VARIABLES

field assessments include: sensory and technical inspections, vibration analysis

diagnostic and test equipment includes: multimeters, clamp-on ammeters, thermographic imaging devices, non-contact temperature sensor, vibration sensor and analyser

electrical components include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, discrete and analog sensors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-18.03.01L	demonstrate knowledge of the complete ***HVAC system and associated equipment*** and the individual ***electrical components***	identify terminology associated with ***HVAC system and associated equipment*** and the individual ***electrical components***
		identify types of ***HVAC systems and associated equipment*** and describe their characteristics, applications and operation
C-18.03.02L	demonstrate knowledge of the interaction between the individual ***electrical components*** and their effect on the ***HVAC system***	identify how the operation or failure of an individual component impacts other components or the complete system
C-18.03.03L	demonstrate knowledge of the procedures used to maintain HVAC ***electrical components***	describe the procedures used to troubleshoot faults in ***electrical components***
		describe the procedures used to repair and replace ***electrical components***

	describe the procedures used to adjust and reprogram ***electrical components***
	describe the procedures used to verify operation of the repaired ***electrical components***

RANGE OF VARIABLES

HVAC systems and associated equipment include: circulating pumps, dampers, boilers, air compressors, refrigeration compressors, condensers, evaporators, chillers

electrical components include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, 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.

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 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

Essential Skills	Numeracy, Document Use, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-19.01.01P	determine type of ***electric heating system***, and type and ratings of ***controls*** required	type of ***electric heating system*** is selected to match the application and type and rating of ***controls*** is selected to meet system requirements
C-19.01.02P	determine size of ***electric heating system*** required using ***heat loss calculations***	size of ***electric heating system*** is selected to match the application and according to the AHJ

C-19.01.03P	calculate demand load	calculations are completed according to CEC requirements and AHJ
C-19.01.04P	determine branch circuit requirements	branch circuit requirements are determined according to CEC requirements and AHJ
C-19.01.05P	determine installation location for heating device	heating device locations are determined considering CEC requirements, manufacturers' specifications, company and client requirements, and AHJ
C-19.01.06P	select feeder and/or branch circuit wiring	feeder and/or branch circuit wiring is selected according to CEC requirements, drawings, specifications, and company and client 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 the circuit conductors are identified, selected and installed according to drawings, specifications, CEC requirements and AHJ
C-19.01.08P	install electrical heating device	heating device is installed according to CEC requirements and manufacturers' specifications
C-19.01.09P	install ***controls***	heating controls are installed based on existing systems and according to CEC requirements and manufacturers' specifications
C-19.01.10P	terminate conductors	cables and conductors are terminated according to drawings, manufacturers' specifications and CEC requirements
C-19.01.11P	test operation	operation is verified by testing the circuit voltage, amperage and controls
C-19.01.12P	determine requirements for removal of ***electric heating systems*** and ***controls***	removal requirements are determined according to environmental regulations, company and client requirements and considering the impact removal will have on the facility
C-19.01.13P	remove existing ***electric heating systems*** and ***controls***	***electric heating systems*** and ***controls*** 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, low voltage thermostats, low voltage relays, temperature limit switches, temperature digital controllers

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 ***electric heating systems*** and ***controls***, their applications and operation	identify terminology associated with ***electric heating systems*** and ***controls***
		identify types of ***electric heating systems*** and describe their applications and operation
		identify types of electric heating ***controls*** and describe their applications and operation
		interpret codes, standards and regulations pertaining to sizing and installing ***electric heating systems*** and ***controls***
C-19.01.02L	demonstrate knowledge of the procedures used to remove and install ***electric heating systems*** and ***controls***	identify the considerations and requirements for the removal of ***electric heating systems*** and ***controls*** including safety and loss of heating capacity
		identify the considerations and requirements for selecting ***electric heating systems*** and ***controls*** and their components including existing controls and systems, service capacity, and heating application
		describe the procedures used to ***calculate heat loss***
		describe the procedures to remove ***electric heating systems*** and ***controls***
		describe the procedures used to install ***electric heating systems*** and ***controls***

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, low voltage thermostats, low voltage relays, temperature limit switches, temperature digital controllers

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

Essential Skills	Document Use, Numeracy, Digital Technology

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-19.02.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** to verify operation of the system	equipment operation is verified according to manufacturers' specifications and operational requirements
C-19.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
C-19.02.03P	identify and remove defective ***electric heating system*** components	defective component is removed without damage to system or other components
C-19.02.04P	select replacement components	replacement components are selected according to manufacturers' specifications and to match the application
C-19.02.05P	install replacement components	components are installed with minimal disruptions and interruptions according to manufacturers' specifications
C-19.02.06P	conduct tests of ***electric heating systems*** and ***controls*** after repair	***electric heating systems*** and ***controls*** are connected and functioning according to manufacturers', company and client specifications and the system operation is verified
C-19.02.07P	clean and adjust components	***electric heating systems*** and ***controls*** components are restored to operating conditions
C-19.02.08P	update maintenance log	maintenance log is updated to reflect tasks performed

RANGE OF VARIABLES

field assessments include: sensory and 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, low voltage thermostats, low voltage relays, temperature limit switches, temperature digital controllers

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-19.02.01L	demonstrate knowledge of ***electric heating systems*** and ***controls***	identify terminology associated with ***electric heating systems*** and ***controls***
		identify types of ***electric heating systems*** and ***controls*** and their components and describe their characteristics, applications and operation
		describe the operation of the ***electric heating system and controls***
C-19.02.02L	demonstrate knowledge of the procedures used to maintain ***electric heating systems*** and ***controls***	describe the procedures used to troubleshoot faults in ***electric heating systems*** and ***controls***
		describe the procedures used to repair or replace ***electric heating systems*** and ***controls***
		describe the procedures used to verify the operation of repaired ***electrical heating systems*** and ***controls***

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, low voltage thermostats, low voltage 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 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

Essential Skills	Document Use, Reading, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-20.01.01P	determine type, size and capacity of ***exit and emergency lighting system*** required and the associated installation requirements	type, size and capacity of ***exit and emergency lighting system*** is selected for the application according to drawings, specifications, CEC requirements and AHJ
C-20.01.02P	calculate connected load and determine branch circuit requirements and standby energy source	calculations are completed according to CEC requirements and AHJ with consideration of voltage drop
C-20.01.03P	determine installation location for ***exit and emergency lighting system***	exit and emergency lighting system locations are determined according to drawings and specifications, and AHJ and NBC requirements
C-20.01.04P	select branch circuit wiring	branch circuit wiring is selected according to CEC requirements, drawings, specifications, and company and client requirements

C-20.01.05P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation, without stress and the circuit conductors are identified, selected and installed according to drawings, specifications, CEC requirements and AHJ
C-20.01.06P	install exit and emergency lighting devices	exit and emergency lighting devices are installed according to drawings, specifications, CEC requirements and AHJ
C-20.01.07P	terminate conductors	cables and conductors are terminated according to drawings, manufacturers' specifications and CEC requirements
C-20.01.08P	test operation	operation is confirmed by testing the circuit for specified voltage, lighting levels and duration of operation
C-20.01.09P	complete documentation	test results are documented according to CEC requirements and AHJ
C-20.01.10P	determine requirements for removal of ***exit and emergency lighting system***	removal requirements are determined according to environmental regulations, company and client requirements and considering the impact removal will have on the facility
C-20.01.11P	remove and dispose of existing ***exit and emergency lighting system*** and update documentation	***exit and emergency lighting system*** is removed and disposed of according to jurisdictional and federal legislation, and waste disposal requirements
C-20.01.12P	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 and associated wiring components and circuits

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-20.01.01L	demonstrate knowledge of ***exit and emergency lighting systems***, their applications and operation	identify terminology associated with ***exit and emergency lighting systems***
		identify types of ***exit and emergency lighting systems*** and describe their applications and operation
		interpret information pertaining to ***exit and emergency lighting systems*** found on drawings and specifications
		identify exit and emergency lighting components and describe their characteristics and applications

		interpret codes, standards and regulations pertaining to ***exit and emergency lighting systems***
C-20.01.02L	demonstrate knowledge of the procedures used to remove and install ***exit and emergency lighting systems*** and their components	identify the considerations, calculations and requirements for selecting ***exit and emergency lighting systems*** and their components
		describe the procedures to remove ***exit and emergency lighting systems*** and their components
		describe the procedure used to install ***exit and emergency lighting systems*** and their components
		describe the procedures used to test ***exit and emergency lighting systems*** and their components and complete the documentation
		identify the considerations and requirements for the removal and disposal of ***exit and emergency lighting systems*** and their components

RANGE OF VARIABLES

exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting units and associated wiring components and circuits

C-20.02 Maintains exit and emergency lighting systems

Essential Skills Document Use, Thinking, Writing

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-20.02.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** to verify operation of equipment	equipment operation is verified according to manufacturers' specifications and operational requirements
C-20.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on ***inspection*** and ***diagnostic and test equipment*** results
C-20.02.03P	identify, remove and dispose of defective components of ***exit and emergency lighting systems***	defective component is removed and disposed of according to jurisdictional and federal legislation, and waste disposal requirements

C-20.02.04P	repair malfunctioning components	repaired components are operational
C-20.02.05P	select replacement components	replacement components (OEM replacement when mandated) match the application
C-20.02.06P	install replacement components	components are installed with minimal disruptions and interruptions according to manufacturers' specifications
C-20.02.07P	conduct tests of ***exit and emergency lighting system*** after repair or component replacement	***exit and emergency lighting system*** are connected and functioning according to manufacturers', company and client specifications, CEC requirements and AHJ and the system operation is verified
C-20.02.08P	document tests in maintenance schedule	operational problems are identified in maintenance schedule data

RANGE OF VARIABLES

field assessments include: sensory and technical inspections
diagnostic and test equipment includes: multimeter, lumen meters
inspections include: sensory inspections, physical condition, location
exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting unit, associated wiring components and circuits

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-20.02.01L	demonstrate knowledge of ***exit and emergency lighting systems***, their applications and operation	identify terminology associated with ***exit and emergency lighting systems***
		identify types of ***exit and emergency lighting systems*** and describe their applications and operation
		identify exit and emergency lighting system components and describe their applications and operation
C-20.02.02L	demonstrate knowledge of the procedures used to maintain ***exit and emergency lighting systems***	describe the procedures used to maintain ***exit and emergency lighting systems*** and their components
		describe the requirements to record and document test results

RANGE OF VARIABLES

exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting units and associated wiring components and circuits

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 oxidization. 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 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

Essential Skills Working with Others, Document Use, Reading

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
C-21.01.01P	determine installation location for ***cathodic protection system components***	***cathodic protection system components*** installations are determined considering manufacturers’ specifications, company and client requirements, CEC requirements and AHJ
C-21.01.02P	select branch circuit wiring	branch circuit wiring is selected according to manufacturers’ specifications and CEC requirements
C-21.01.03P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation, without stress and the circuit conductors are identified, selected and installed according to drawings, specifications, CEC requirements and AHJ
C-21.01.04P	install ***cathodic protection system components***	***cathodic protection system components*** are installed according to manufacturers’ specifications and CEC requirements and AHJ
C-21.01.05P	terminate conductors	cables and conductors are terminated according to drawings, manufacturers’ specifications and CEC requirements

C-21.01.06P	test operation	operation is confirmed by testing the circuit for specified requirements according to manufacturers' specifications
C-21.01.07P	determine requirements for removal of ***cathodic protection system components***	removal requirements are determined according to environmental regulations, company and client requirements and considering the impact removal will have on the facility
C-21.01.08P	remove existing ***cathodic protection systems components***	***cathodic protection system components*** are removed and disposed of according to jurisdictional and federal legislation, and waste disposal requirements
C-21.01.09P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

cathodic protection system components include: AC supply, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-21.01.01L	demonstrate knowledge of cathodic protection systems, their applications and operation	identify terminology associated with cathodic protection systems
		identify types of cathodic protection systems, and describe their characteristics, applications and operation
		identify cathodic protection systems and their ***components*** 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 the procedures used to install, connect, and test cathodic protection systems	describe the procedures used to install cathodic protection systems and their ***components***
		describe the procedures used to test cathodic protection systems and their ***components***

RANGE OF VARIABLES

cathodic protection system components include: AC supply, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling

C-21.02 Maintains cathodic protection systems

Essential Skills Document Use, Writing, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
C-21.02.01P	conduct ***field assessments*** using ***diagnostic and test equipment*** to verify operation of equipment	equipment operation is verified according to manufacturers' specifications and AHJ
C-21.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on inspection and ***diagnostic and test equipment*** results
C-21.02.03P	identify and remove defective ***cathodic protection system components***	defective ***cathodic protection system components*** are removed and disposed of according to jurisdictional and federal legislation, and waste disposal requirements
C-21.02.04P	repair malfunctioning ***cathodic protection system components***	repaired ***cathodic protection system components*** are operational
C-21.02.05P	select replacement ***cathodic protection system components***	replacement ***cathodic protection system components*** (OEM replacement when mandated) match the application
C-21.02.06P	install replacement ***cathodic protection system components***	***cathodic protection system components*** are installed according to manufacturers' specifications and AHJ
C-21.02.07P	conduct tests of ***cathodic protection system components*** after repair	***cathodic protection system components*** are connected and functioning according to manufacturers', company and client specifications, CEC requirements and AHJ and the system operation is verified
C-21.02.08P	document test results in maintenance document	operational problems are identified in maintenance schedule data

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeter

cathodic protection system components include: AC supply, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
C-21.02.01L	demonstrate knowledge of cathodic protection systems, their applications and operation	identify terminology associated with cathodic protection systems
		identify types of ***cathodic protection systems and components*** and describe their applications and operation
C-21.02.02L	demonstrate knowledge of the procedures used to maintain cathodic protection systems	describe the procedures used to maintain cathodic protection systems

RANGE OF VARIABLES

cathodic protection system components include: AC supply, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling

MAJOR WORK ACTIVITY D

Installs and maintains rotating and non-rotating 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, 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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills	Thinking, Document Use, Numeracy

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
D-22.01.01P	determine type of ***motor starter*** for specific application	***motor starter*** is selected and sized according to the application and according to drawings, specifications, motor ***manufacturers’ nameplate data***, standards and codes
D-22.01.02P	calculate conductor requirements	conductor type and size match the application and CEC requirements
D-22.01.03P	remove existing ***motor starter*** when replacing	motor starter is removed with minimal impact to the surrounding equipment and interruptions to operation
D-22.01.04P	position, mount and assemble ***starter assembly***	***starter assembly*** is placed, mounted and assembled in locations according to electrical drawings, and job, company and client requirements

D-22.01.05P	terminate cables	cables are terminated according to manufacturers' specifications and CEC requirements
D-22.01.06P	terminate conductors	conductors are terminated according to manufacturers' and CEC torque specifications, temperature ratings and point of termination
D-22.01.07P	install ***overcurrent protection devices***	***overcurrent protection devices*** are sized to manufacturers' specifications and CEC requirements
D-22.01.08P	set overloads	overloads are sized for the application and adjusted to provide motor running protection according to manufacturers' specifications and CEC requirements
D-22.01.09P	interconnect starter with ***motor control devices*** and ***indicators***	interconnections are completed and equipment functions as intended
D-22.01.10P	verify function of ***motor starter***	***motor starter*** is functioning according to application
D-22.01.11P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

motor starters include: starters for AC/DC motors, single phase, three phase AC, line voltage starters, soft starters, reduced-voltage starters

manufacturers' nameplate data includes: size of motor, full load current (FLC), service factor, voltage, duty

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

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-22.01.01L	demonstrate knowledge of ***motor starters*** and their applications	interpret information pertaining to ***motor starters*** found on motor nameplate, drawings and specifications
		describe ***motor starters*** and their applications
		interpret codes and regulations pertaining to ***motor starters***
D-22.01.02L	demonstrate knowledge of procedures used to install and connect ***motor starters***	describe the procedures used to install ***motor starters***, their components and accessories

	describe the procedures used to connect ***motor starters***, their components and accessories
	identify enclosures and wiring methods based on application

RANGE OF VARIABLES

motor starters include: starters for AC/DC motors, single phase, three phase AC, line voltage starters, soft starters, reduced-voltage starters

D-22.02 Maintains motor starters

Essential Skills Oral Communication, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-22.02.01P	obtain description of operation of motor starter	required information about equipment operation is gathered from end user
D-22.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment*** to determine source of malfunction	source of malfunction is identified based on ***diagnostic equipment*** results
D-22.02.03P	identify and remove defective components of motor starters	defective component is removed without damage to system or other components
D-22.02.04P	repair malfunctioning components	repaired components are operational
D-22.02.05P	select replacement components	replacement components match the application
D-22.02.06P	replace defective or damaged components	components are replaced with minimal disruptions and interruptions
D-22.02.07P	clean, lubricate and ***adjust*** components	motor starter components are restored to OEM ***component conditions***
D-22.02.08P	conduct tests of motor starters after repair	starter assembly is connected and functions according to manufacturers', company and client specifications
D-22.02.09P	document test results in maintenance schedule	operational problems are identified and documented in maintenance schedule data with detailed notations
D-22.02.10P	compare and analyze maintenance test results	maintenance is performed when required based on analysis of test results and comparison with specifications

D-22.02.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-22.02.12P	update documentation	images and drawings reflect operational changes and maintenance history is documented

RANGE OF VARIABLES

field assessments include: sensory and technical inspections
diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters
adjustment procedures include: re-torquing of 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 ***motor starters*** and their applications	interpret information pertaining to ***motor starters*** found on drawings and specifications
		describe ***motor starters*** and their applications
		interpret codes and regulations pertaining to ***motor starters***
D-22.02.02L	demonstrate knowledge of procedures used to maintain ***motor starters***	describe the procedures used to maintain ***motor starters***, their components and accessories

RANGE OF VARIABLES

motor starters include: starters for AC/DC motors, single phase, three phase AC, line voltage starters, soft starters, reduced-voltage starters

D-22.03 Installs motor control devices

Essential Skills	Thinking, Numeracy, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-22.03.01P	determine type of ***motor control device*** and ***function*** for specific application	***motor control device*** is selected according to the application
D-22.03.02P	determine ***motor control circuit*** and ***circuit functional features***	***motor control circuit*** types are selected for the specific application and CEC requirements
D-22.03.03P	calculate conductor requirements	conductor type and size match the application and CEC requirements
D-22.03.04P	remove existing ***motor control device*** when replacing	***motor control device*** is removed with minimal impact to the surrounding equipment and interruptions to operation
D-22.03.05P	position, mount and assemble ***motor control device***	***motor control device*** is placed, mounted and assembled in locations according to electrical drawings, job and client requirements
D-22.03.06P	terminate cables	cables are terminated according to CEC requirements
D-22.03.07P	terminate conductors	conductors are terminated according to manufacturers' torque specifications, temperature ratings and point of termination
D-22.03.08P	set up and adjust ***motor control devices***	***motor control devices*** operate according to application
D-22.03.09P	interconnect ***motor control devices*** with ***indicators***	interconnections are completed and equipment functions as intended
D-22.03.10P	interconnect ***motor control devices*** with overload protection	interconnections are completed and equipment functions as intended
D-22.03.11P	conduct tests of ***motor control devices*** after installation and document results	***motor control devices*** are connected and function according to manufacturers', company and client specifications

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, time function

indicators include: indicating lights, audible devices

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-22.03.01L	demonstrate knowledge of ***motor control devices*** and their applications	interpret information pertaining to ***motor control devices*** found on drawings and specifications
		describe ***motor control devices*** and their applications
		interpret codes and regulations pertaining to ***motor control devices***
D-22.03.02L	demonstrate knowledge of ***motor control circuits***, their characteristics and applications	interpret codes and regulations pertaining to ***motor control circuits***
		identify ***circuit types*** and describe their characteristics and applications
		describe ***circuit functional features*** of common hard wired or networked motor control circuits
		identify the methods used to determine the number of conductors required between controls and controller locations
		identify ***protection devices*** for ***motor control circuits*** and describe characteristics and applications

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, time function

protection devices for control circuits include: overcurrent devices

D-22.04 Maintains motor control devices

Essential Skills	Oral Communication, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-22.04.01P	obtain description of trouble of ***motor control devices***	required information about equipment operation is gathered from end user
D-22.04.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic and test equipment*** results
D-22.04.03P	identify and remove defective components and ***motor control devices***	defective components and ***motor control devices*** are removed without damage to system or other components
D-22.04.04P	clean, lubricate and ***adjust*** components and ***motor control devices***	components and ***motor control devices*** are restored to OEM ***conditions***
D-22.04.05P	select replacement components and ***motor control devices***	replacement components and ***motor control devices*** are selected according to application
D-22.04.06P	install replacement components and ***motor control devices***	components and ***motor control devices*** are installed with minimal disruptions and interruptions
D-22.04.07P	conduct tests of ***motor control devices*** after repair	control assembly is connected and functions according to manufacturers', company and client specifications
D-22.04.08P	document test results in maintenance schedule	operational problems are identified and documented in maintenance schedule data with detailed notations
D-22.04.09P	compare and analyze maintenance test results	maintenance is performed when required based on analysis of test results and comparison with specifications
D-22.04.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-22.04.11P	update documentation	documentation reflect operational changes and maintenance history is 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)

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters

adjustments include: re-torquing of terminations, calibration of components

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 ***motor control devices*** and their applications	interpret information pertaining to ***motor control devices*** found on drawings and specifications
		describe ***motor control devices*** and their applications
		interpret codes and regulations pertaining to ***motor control devices***
D-22.04.02L	demonstrate knowledge of procedures used to maintain ***motor control devices*** and their components	describe the procedures used to maintain ***motor control devices*** 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 the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Document Use, Numeracy, Thinking

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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 the application and ***motor nameplate data***
D-23.01.02P	calculate conductor and reactor requirements	conductor and reactor type and size match the application and take into account ***conditions*** and CEC requirements
D-23.01.03P	remove existing AC drives when replacing	AC drive is removed with minimal impact to the surrounding equipment and interruption to operation
D-23.01.04P	position, mount and assemble AC drives	AC drive is placed, mounted and assembled in locations according to electrical drawings, manufacturers’ specifications and company and client requirements
D-23.01.05P	terminate cables and conductors	cables and conductors are terminated according to manufacturers’ specifications and CEC requirements
D-23.01.06P	install ***overcurrent protection devices***	***overcurrent protection devices*** are sized to manufacturers’ specifications and CEC requirements
D-23.01.07P	program AC drives	programming meet functionality and established parameters

D-23.01.08P	interconnect AC drives to ***motor control devices***	interconnections are completed with required cables, raceways and conductors and equipment functions as intended
D-23.01.09P	conduct tests of AC drive after installation	AC drive is connected and functions according to manufacturers' specifications, and company and client specifications and results are documented
D-23.01.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled to ensure installation
D-23.01.11P	update documentation	documentation reflect operational changes and maintenance history and parameters are documented

RANGE OF VARIABLES

motor nameplate data includes: size of motor, FLC, inverter duty rated, voltage

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 types of AC drives, their applications and operation	identify types of AC drives and describe their characteristics, applications and operation
		identify ***AC drive components*** 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
D-23.01.02L	demonstrate knowledge of procedures used to install and connect AC drives	identify the considerations and requirements for selecting AC drives and their ***components***
		describe the procedures used to install AC drives and their ***components***
		describe the procedures used to program AC drives and their ***components***

RANGE OF VARIABLES

AC drive components include: rectifiers, electro-magnetic compatibility (EMC) filters, DC circuits, inverters, reactors, field components (e.g. encoders, tachometers)

D-23.02 Maintains AC drives

Essential Skills Thinking, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-23.02.01P	obtain description of trouble of AC drives	required information about equipment operation is gathered from end user
D-23.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on diagnostic equipment results
D-23.02.03P	identify and remove defective ***components*** of AC drives	defective ***components*** are removed with minimal impact to the surrounding equipment and interruption to operation
D-23.02.04P	select replacement ***components***	replacement ***components*** match the application
D-23.02.05P	install replacement ***components***	***components*** are installed with minimal disruptions and interruptions
D-23.02.06P	repair malfunctioning ***components***	repaired ***components*** are operational
D-23.02.07P	conduct tests of AC drives after repair	AC drive assembly is connected and functions according to manufacturers', company and client specifications
D-23.02.08P	***clean and adjust*** components	***AC drive components*** are restored to optimal conditions
D-23.02.09P	compare and analyze ***drive parameters***	maintenance is performed based on analysis of ***drive parameters***
D-23.02.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled for installation
D-23.02.11P	update documentation	documentation reflects operational changes and maintenance history and parameters are documented

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters, oscilloscopes

cleaning and adjustment include: re-torquing of terminations, cleaning filters and cooling fans, checking door seals

AC drive components include: rectifiers, EMC filters, DC circuits, inverters, reactors, field components (e.g. encoders, tachometers)

drive parameters include: overload, accel/decel rate, torque, frequency, braking

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-23.02.01L	demonstrate knowledge of types of AC drives, their applications and operation	identify types of AC drives and describe their characteristics, applications and operation
		identify ***AC drive components*** 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 used to maintain AC drives	describe the procedures used to maintain AC drives and their ***components***

RANGE OF VARIABLES

AC drive components include: rectifiers, EMC filters, DC circuits, inverters

D-23.03 Installs DC drives

Essential Skills Document Use, Numeracy, Thinking

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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 the application and ***motor nameplate data***
D-23.03.02P	calculate conductor requirements	conductor type and size match the application to manufacturers' specifications and CEC requirements
D-23.03.03P	remove existing DC drives when replacing	DC drive is removed with minimal impact to the surrounding equipment and interruption to operation
D-23.03.04P	position, mount and assemble DC drives	DC drive is placed in locations according to electrical drawings, manufacturers' specifications, and company and client requirements
D-23.03.05P	terminate conductors and cables	conductors and cables are terminated according to manufacturers' specifications and CEC
D-23.03.06P	install ***overcurrent protection devices***	***overcurrent protection devices*** are sized to manufacturers' specifications and CEC requirements
D-23.03.07P	program DC drives	programming meets functionality and established parameters
D-23.03.08P	interconnect DC drives to ***motor control devices*** with cables, raceways and conductors	interconnections are completed and equipment functions as intended
D-23.03.09P	conduct tests of DC drive after installation and document results	DC drive is connected and functions according to manufacturers', company and client specifications
D-23.03.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to electrical drawings
D-23.03.11P	update documentation	documentation reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

motor nameplate data includes: size of motor, FLC, voltage

overcurrent protection devices include: fuses, inverse time circuit breakers, instantaneous 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 types of DC drives, their applications and operation	identify types of DC drives and describe their characteristics, applications and operation
		identify ***DC drive components*** 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-23.03.02L	demonstrate knowledge of procedures used to install and connect DC drives	identify the considerations and requirements for selecting DC drives and their ***components***
		describe the procedures used to install DC drives and their ***components***
		describe the procedures used to connect DC drives and their ***components***
		describe the procedures used to program DC drives and their ***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 (e.g. encoders and tachometers)

D-23.04 Maintains DC drives

Essential Skills Thinking, Digital Technology, Writing

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
D-23.04.01P	obtain description of trouble of DC drives	required information about equipment operation is gathered from end user
D-23.04.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic and test equipment*** results
D-23.04.03P	identify and remove defective components of DC drives	defective components are removed with minimal impact to the surrounding equipment and interruption to operation
D-23.04.04P	select replacement components	replacement components match (OEM specifications) the application
D-23.04.05P	install replacement components	components are installed with minimal disruptions and interruptions
D-23.04.06P	repair malfunctioning components	repaired components are operational
D-23.04.07P	conduct tests of DC drives after repair	DC drive assembly is connected and functions according to manufacturers', company and client specifications
D-23.04.08P	***clean and adjust*** components	DC drive components are restored to optimal conditions
D-23.04.09P	compare and analyze ***drive parameters***	maintenance is performed based on analysis of ***drive parameters***
D-23.04.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled for installation
D-23.04.11P	update documentation	documentation reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters, oscilloscopes

cleaning and adjustment include: re-torquing of terminations, cleaning filters and cooling fans, checking door seals

drive parameters include: feedback, accel/decel rate, torque, braking, max speed/base speed, max/min field current

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-23.04.01L	demonstrate knowledge of types of DC drives, their applications and operation	identify types of DC drives and describe their characteristics, applications and operation
		identify ***DC drive components*** 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 used to maintain DC drives	describe the procedures used to maintain DC drives and their ***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 (e.g. encoders and tachometers)

TASK D-24 Installs and maintains non-rotating equipment and associated controls

TASK DESCRIPTOR

Non-rotating equipment includes welding equipment, electro-magnets, electrostatic precipitators and other non-rotating devices not included elsewhere in this standard and their associated controls. Industrial electricians must install and maintain this equipment.

For the purpose of this standard, “install” includes both new installations and upgrading of 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 non-rotating equipment and associated controls

Essential Skills Document Use, Numeracy, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
D-24.01.01P	determine type of ***non-rotating equipment*** and controls	***non-rotating equipment*** and controls are determined according to manufacturers’ specifications, client and CEC requirements
D-24.01.02P	calculate conductor requirements	conductor type and size match the application according to manufacturers’ specifications and CEC requirements
D-24.01.03P	install ***overcurrent protection devices***	***overcurrent protection devices*** are sized to manufacturers’ specifications and CEC requirements
D-24.01.04P	remove existing ***non-rotating equipment*** and controls when replacing	***non-rotating equipment*** and controls are removed with minimal impact to the surrounding equipment and interruption to operation
D-24.01.05P	position, mount and assemble ***non-rotating equipment*** and controls	***non-rotating equipment*** and controls are placed, mounted and assembled in locations according to electrical drawings, manufacturers’ specifications, and company and client requirements
D-24.01.06P	terminate conductors and cables	conductors and cables are terminated according to manufacturers’ specifications and CEC requirements

D-24.01.07P	conduct tests of ***non-rotating equipment*** and controls after installation and document results	***non-rotating equipment*** and controls is connected and functions according to manufacturers', company and client specifications, and results are documented
D-24.01.08P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-24.01.09P	update documentation	documentation reflect changes and maintenance history is documented

RANGE OF VARIABLES

non-rotating equipment includes: welding equipment, electro-magnets, electrostatic precipitators
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 ***non-rotating equipment*** and controls, their applications and procedures for use	identify types of ***non-rotating equipment*** and controls and describe their characteristics
		identify ***non-rotating equipment*** components and describe their applications
		interpret codes and regulations for overcurrent protection, conductor sizing, disconnect locations
		interpret information found on drawings and specifications
		explain operating principles of ***non-rotating equipment*** and controls
		interpret information contained on ***non-rotating equipment*** nameplates
D-24.01.02L	demonstrate knowledge of procedures used to install and connect ***non-rotating equipment*** and controls	describe procedures used to install ***non-rotating equipment*** and controls
		describe procedures used to connect ***non-rotating equipment*** and controls
		identify the considerations and requirements for selecting ***non-rotating equipment*** and controls and their components

RANGE OF VARIABLES

non-rotating equipment includes: welding equipment, electro-magnets, electrostatic precipitators

D-24.02 Maintains non-rotating equipment and associated controls

Essential Skills	Digital Technology, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-24.02.01P	obtain description of trouble of ***non-rotating equipment*** and controls	required information about equipment operation is gathered from end user
D-24.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic and test equipment*** results
D-24.02.03P	identify and remove defective ***components*** of ***non-rotating equipment*** and controls	defective ***components*** are removed without damage to system or other ***components***
D-24.02.04P	select replacement ***components***	replacement ***components*** match the application
D-24.02.05P	install replacement ***components***	***components*** are installed with minimal disruptions and interruptions
D-24.02.06P	conduct ***tests*** of ***non-rotating equipment*** and controls after repair	***non-rotating equipment*** assembly is connected and functions according to specifications to match the application
D-24.02.07P	clean and adjust the ***components***	non-rotating equipment ***components*** are restored to optimal conditions
D-24.02.08P	compare and analyze maintenance ***test*** results	maintenance is performed when required based on analysis of ***test*** results and comparison with specifications
D-24.02.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-24.02.10P	update documentation	documentation reflects changes and maintenance history is documented

RANGE OF VARIABLES

non-rotating equipment includes: welding equipment, electro-magnets, electrostatic precipitators

field assessments include: sensory and technical inspections

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

components include: overcurrent protection, conductors, disconnects

tests include: insulation, current, baseline

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-24.02.01L	demonstrate knowledge of ***non-rotating equipment*** and controls, their applications and operation	identify types of ***non-rotating equipment*** and controls and describe their characteristics
		identify ***non-rotating equipment*** components and describe their applications
		interpret codes and regulations
		interpret found information on drawings and specifications
		explain the industrial and operating principles of ***non-rotating equipment*** and controls
D-24.02.02L	demonstrate knowledge of procedures used to maintain of ***non-rotating equipment*** and controls	describe the procedures used to maintain ***non-rotating equipment*** and controls and their components

RANGE OF VARIABLES

non-rotating equipment includes: welding equipment, electro-magnets, electrostatic precipitators

TASK D-25 Installs and maintains motors

TASK DESCRIPTOR

Motors are used to convert electrical energy to 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 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

Essential Skills Document Use, Thinking, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.01.01P	determine type of ***single-phase motor*** required	type of ***single-phase motor*** is determined according to ***operating considerations***
D-25.01.02P	calculate conductor requirements	conductor type and size match the application and CEC requirements
D-25.01.03P	determine and install overload and overcurrent devices based on requirements	overload and overcurrent devices are installed according to ***motor nameplate data*** and CEC requirements
D-25.01.04P	position and mount ***single-phase motor***	***single-phase motor*** is placed, mounted and assembled according to the application
D-25.01.05P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-25.01.06P	connect motor leads	motor leads are connected according to the application, supply voltage and rotation
D-25.01.07P	conduct ***tests*** of ***single-phase motor*** after installation	***single-phase motor*** is connected and functions according to manufacturers’, company and client specifications and results are documented

D-25.01.08P	remove existing ***single-phase motor*** when replacing	***single-phase motor*** is removed with minimal impact to the environment
D-25.01.09P	update documentation	documentation reflects operational changes and maintenance history is documented

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, FLC, service factor, voltage, duty

tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-25.01.01L	demonstrate knowledge of ***single-phase motors***, their applications and operation	identify types of ***single-phase motors*** and describe their characteristics
		identify terminology pertaining to ***single-phase motors***
		identify single-phase motor components and describe their applications
		interpret codes and regulations
		interpret information on drawings and specifications
		explain operating principles of ***single-phase motors***
		interpret information contained on single-phase motor nameplates
D-25.01.02L	demonstrate knowledge of procedures used to install and connect ***single-phase motors***	describe procedures used to install ***single-phase motors***
		describe procedures used to connect ***single-phase motors***
		identify the ***operating considerations*** and requirements for selecting ***single-phase motors*** and their 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

operating considerations include: torque requirement, voltage availability, motor function, rotation, location

D-25.02 Maintains single-phase motors

Essential Skills	Oral Communication, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.02.01P	obtain description of trouble of single-phase motors	required information about equipment operation is gathered from end user
D-25.02.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic and test equipment*** results
D-25.02.03P	identify and remove defective ***components*** of single-phase motors	defective ***components*** are removed without damage to system or other components
D-25.02.04P	select replacement ***components***	replacement ***components*** match the application
D-25.02.05P	install replacement ***components***	***components*** are installed with minimal disruptions and interruptions
D-25.02.06P	conduct ***tests*** of single-phase motors after repair	single-phase motor assembly is connected and functions according to specifications to match the application
D-25.02.07P	***clean, lubricate and adjust*** components	single-phase motor ***components*** are restored to optimal conditions
D-25.02.08P	document ***test*** results in maintenance schedule	operational problems are identified and documented in maintenance schedule data with detailed notations
D-25.02.09P	compare and analyze maintenance ***test*** results	maintenance is performed when required based on analysis of ***test*** results and comparison with specifications
D-25.02.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled for installation
D-25.02.11P	update documentation	documentation reflects operational changes and maintenance history is documented

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers, vibration analyzer

components include: frame, centrifugal switch, armature, 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 ***single-phase motors***, their applications and operation	identify types of ***single-phase motors*** and describe their characteristics
		identify terminology pertaining to ***single-phase motors***
		identify ***single-phase motor components*** and describe their applications
		interpret codes and regulations
		interpret information found on drawings and specifications
		explain the industrial and operating principles of ***single-phase motors***
		interpret information contained on single-phase motor nameplates
D-25.02.02L	demonstrate knowledge of procedures used to maintain ***single-phase motors***	describe the procedures used to maintain ***single-phase motors*** and their ***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

components include: frame, centrifugal switch, armature, rotor, stator, end bells, fans, bearings, bushings, capacitors

D-25.03 Installs three-phase motors

Essential Skills Document Use, Numeracy, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.03.01P	determine type of ***three-phase motor*** required	type of ***three-phase motor*** is determined according to ***operating considerations***
D-25.03.02P	calculate conductor requirements	conductor type and size match the application and CEC requirements
D-25.03.03P	determine and install overload and overcurrent devices based on requirements	overload and overcurrent devices are installed according to ***motor nameplate data*** and CEC requirements
D-25.03.04P	position and mount ***three-phase motor***	***three-phase motor*** is placed, mounted and assembled according to the application
D-25.03.05P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled for installation
D-25.03.06P	connect motor leads	motor leads are connected according to the application, supply voltage and rotation
D-25.03.07P	conduct ***tests*** of ***three-phase motor*** after installation and document results	***three-phase motor*** is connected and functions according to manufacturers', company and client specifications
D-25.03.08P	remove existing ***three-phase motor*** when replacing	***three-phase motor*** is removed with minimal impact to the environment
D-25.03.09P	update documentation	documentation reflects changes and maintenance history is documented

RANGE OF VARIABLES

three-phase motors include: squirrel cage induction, synchronous, wound rotor induction, linear induction

operating considerations include: supply voltage, motor function, rotation, location

motor nameplate data includes: size of motor, FLC, service factor, voltage

tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-25.03.01L	demonstrate knowledge of ***three-phase motors***, their applications and procedures for use	identify types of ***three-phase motors*** and describe their characteristics
		identify terminology pertaining to ***three-phase motors***
		identify three-phase motor components and describe their applications
		interpret codes and regulations
		interpret information found on drawings and specifications
		explain the operating principles of ***three-phase motors***
		interpret information contained on three-phase motor nameplates
D-25.03.02L	demonstrate knowledge of procedures used to install and connect ***three-phase motors***	describe procedures used to install ***three-phase motors***
		describe procedures used to connect ***three-phase motors***
		identify the considerations and requirements for selecting ***three-phase motors*** and their components

RANGE OF VARIABLES

three-phase motors include: squirrel cage induction, synchronous, wound rotor induction, linear induction

D-25.04 Maintains three-phase motors

Essential Skills	Oral Communication, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.04.01P	obtain description of trouble of ***three-phase motors***	required information about equipment operation is gathered from end user
D-25.04.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic and test equipment*** results
D-25.04.03P	identify and remove defective ***components*** of ***three-phase motors***	defective ***components*** are removed without damage to system or other components
D-25.04.04P	select replacement components	replacement components match the application
D-25.04.05P	install replacement components	components are installed with minimal disruptions and interruptions
D-25.04.06P	conduct ***tests*** of ***three-phase motors*** after repair	***three-phase motor*** assembly is connected and functions according to specifications to match the application
D-25.04.07P	***clean, lubricate and adjust*** components	***three-phase motor components*** are restored to optimal conditions
D-25.04.08P	document ***test*** results in maintenance schedule	operational problems are identified and documented in maintenance schedule data with detailed notations
D-25.04.09P	compare and analyze maintenance ***test*** results	maintenance is performed when required based on analysis of ***test*** results and comparison with specifications
D-25.04.10P	label conductors and corresponding terminals or leads	conductors and corresponding terminals or leads are labelled
D-25.04.11P	update documentation	documentation reflects changes and maintenance history is documented

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

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

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 ***three-phase motors***, their applications and operation	identify types of ***three-phase motors*** and describe their characteristics
		identify terminology pertaining to ***three-phase motors***
		identify ***three-phase motor components*** and describe their applications
		interpret codes and regulations
		interpret information found on drawings and specifications
		explain the operating principles of ***three-phase motors***
		interpret information contained on three-phase motor nameplates
D-25.04.02L	demonstrate knowledge of procedures used to maintain ***three-phase motors***	describe the procedures used to maintain ***three-phase motors*** and their ***components***

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

Essential Skills Numeracy, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.05.01P	determine type of ***DC motor*** required	***DC motor*** to be installed meets ***operating conditions***
D-25.05.02P	calculate conductor requirements	conductor type and size match the application and CEC requirements
D-25.05.03P	determine and install overload and overcurrent devices based on requirements	overload and overcurrent devices are installed according to ***motor nameplate data*** and CEC requirements
D-25.05.04P	remove existing ***DC motors*** when replacing	***DC motors*** are removed with minimal impact to the environment
D-25.05.05P	position and mount ***DC motor***	***DC motor*** is placed and mounted according to the application
D-25.05.06P	connect motor leads	motor leads are connected according to the application, supply voltage, rotation and configuration
D-25.05.07P	conduct ***tests*** of ***DC motor*** after installation	***DC motor*** is connected and functions according to manufacturers', company and client specifications, and results are documented
D-25.05.08P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled
D-25.05.09P	update documentation	documentation reflect changes and maintenance history is documented

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, size of motor, FLC, service factor, voltage
tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-25.05.01L	demonstrate knowledge of ***DC motors***, their applications and procedures for use	identify types of ***DC motors*** and describe their characteristics and applications
		identify terminology pertaining to ***DC motors***
		identify ***DC motor components*** and describe their characteristics and applications
		interpret codes and regulations
		interpret information found on drawings and specifications
		explain operating principles of ***DC motors***
		interpret information contained on DC motor nameplates
D-25.05.02L	demonstrate knowledge of procedures used to install and connect ***DC motors***	identify considerations and requirements for selecting ***DC motors*** and controls, and their ***components***
		describe the procedures used to install ***DC motors*** and controls, and their ***components***
		describe the procedures used to connect ***DC motors*** and controls and their ***components***

RANGE OF VARIABLES

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination

DC motor components include: frame, armature, rotor, stator, commutator, end bells, fans, brushes, brush holders, bearings, bushings

D-25.06 Maintains DC motors

Essential Skills Oral Communication, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
D-25.06.01P	obtain description of trouble of ***DC motors***	required information about equipment operation is gathered from end user
D-25.06.02P	conduct ***field assessments*** using ***diagnostic and test equipment***	source of malfunction is identified based on ***diagnostic equipment*** results
D-25.06.03P	identify and remove defective components of ***DC motors***	defective components are removed without damage to system or other components
D-25.06.04P	select replacement components	replacement components (OEM specifications) are selected to match the application
D-25.06.05P	install replacement components	components are installed with minimal disruptions and interruptions
D-25.06.06P	conduct ***tests*** of ***DC motors*** after repair	***DC motor*** assembly is connected and functions according to manufacturers', company and client specifications
D-25.06.07P	***clean, lubricate and adjust*** components	***DC motor components*** are restored to optimal conditions
D-25.06.08P	document test results in maintenance schedule	operational problems are identified and documented in maintenance schedule data with detailed notations
D-25.06.09P	compare and analyze maintenance ***test*** results	maintenance is performed when required based on analysis of ***test*** results and comparison with specifications
D-25.06.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled for installation
D-25.06.11P	update documentation	documentation reflects changes and maintenance history is documented

RANGE OF VARIABLES

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination

field assessments include: sensory and 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, rotor, stator, commutator, end bells, fans, brushes, brush holders, bearings, bushings

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
D-25.06.01L	demonstrate knowledge of ***DC motors***, their applications and procedures for use	identify types of ***DC motors*** and describe their characteristics and applications
		identify terminology pertaining to ***DC motors***
		identify ***DC motor components*** and describe their characteristics and applications
		interpret codes and regulations
		interpret information found on drawings and specifications
		explain operating principles of ***DC motors***
		interpret information contained on DC motor nameplates
D-25.06.02L	demonstrate knowledge of procedures used to maintain ***DC motors***	describe the procedures used to maintain ***DC motors*** and their ***components***

RANGE OF VARIABLES

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination

DC motor components include: frame, armature, rotor, stator, 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 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

Essential Skills Document Use, Reading, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
E-26.01.01P	identify type of ***fire alarm system*** required for new installation	type of ***fire alarm system*** is identified according to ***AHJ***, electrical drawings, specifications and job requirements
E-26.01.02P	remove and dispose of existing ***fire alarm system*** when replacing	all ***fire alarm system components*** are disposed of according to codes and waste disposal requirements
E-26.01.03P	determine ***fire alarm system*** layout	***fire alarm system*** layout is determined according to walkthrough of building to identify and mark interference locations on drawings according to ***AHJ*** and manufacturers’ specifications
E-26.01.04P	select ***fire alarm system components***	***fire alarm system components*** are selected according to electrical drawings, and manufacturers’ specifications and ***AHJ***

E-26.01.05P	position, mount and assemble ***fire alarm system components***	***fire alarm system components*** are placed, mounted and assembled in locations according to electrical drawings, job requirements and ***AHJ***
E-26.01.06P	terminate and interconnect ***fire alarm system components*** and ***associated systems***	***fire alarm system components*** and ***associated system*** devices are terminated and interconnected according to electrical drawings, manufacturers' specifications, job requirements and ***AHJ***
E-26.01.07P	test ***fire alarm system components***	fire alarm system functions are tested to ensure functionality
E-26.01.08P	test cables	cables are tested for continuity, shorts and conductors are not grounded
E-26.01.09P	conduct an initial test of the ***fire alarm system***	sensory and spot tests and initial ***fire alarm system*** tests are performed according to manufacturers' specifications, and ***AHJ***
E-26.01.10P	participate in start-up, commissioning and verification	start-up, commissioning and verification is conducted on ***fire alarm system***, ***fire alarm system components*** and ***associated systems*** according to design and manufacturers' specifications and ***AHJ***
E-26.01.11P	update ***documentation*** for fire alarm systems	***documentation*** is updated according to ***AHJ*** and reflects commissioning activities

RANGE OF VARIABLES

fire alarm systems include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems such as 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, 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

AHJ includes: Underwriters Laboratory of Canada, Canadian Electrical Code, National Fire Code of Canada, National Building Code, and Local Building Codes, CSA standard M421, local fire codes

documentation includes: maintenance logs, inspection reports, as-built drawings, panel schedules, site visit log, commissioning documents, fire alarm verification report form

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
E-26.01.01L	demonstrate knowledge of types of ***fire alarm systems***, their applications and operation	interpret ***codes, standards and regulations*** pertaining to ***fire alarm systems***
		interpret information found on drawings and manufacturers' specifications
		identify types of ***fire alarm systems*** and describe their characteristics and applications
		describe types of ***associated systems*** that are interconnected with ***fire alarm systems***
		identify ***fire alarm system components*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***fire alarm systems***, and their ***components***
E-26.01.02L	demonstrate knowledge of the procedures used to install, upgrade and connect ***fire alarm systems***, their ***components and connections to associated systems***	describe the procedures used to install, upgrade and connect ***fire alarm systems*** and their ***components***
		describe procedures used to interconnect ***associated/ancillary systems*** with ***fire alarm systems***
		describe procedures for testing ***fire alarm systems*** and their ***components***
		describe the procedures for the 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 such as single stage, two stage, single zone, multi-zone

codes, standards and regulations include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC, National Fire Code (NFC) and 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

Essential Skills Thinking, Document Use, Reading

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-26.02.01P	obtain description of trouble of ***fire alarm system*** from user	malfunction issues and ***information*** is obtained and description of problem is noted
E-26.02.02P	identify existing ***fire alarm system*** and ***components***	existing ***fire alarm system*** and ***components*** are identified from ***documentation***
E-26.02.03P	test ***fire alarm system***	tests are performed according to AHJ, manufacturers' specifications and maintenance schedule; sensory inspections and technical inspections are performed using ***diagnostic and test equipment***
E-26.02.04P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-26.02.05P	participate in periodic inspections	***fire alarm system, fire alarm system components,*** and ***associated/ancillary systems*** function according to manufacturers' specifications and are inspected according to maintenance schedule
E-26.02.06P	select replacement components	replacement components are selected according to manufacturers' specifications, company and client specifications and ***AHJ***
E-26.02.07P	replace ***fire alarm system*** components	replacement ***components*** are tested and verified according to ***AHJ***
E-26.02.08P	update ***documentation***	***documentation*** is clear, detailed and includes systems and components tested, the test results and changes that were completed according to ***AHJ***

RANGE OF VARIABLES

fire alarm systems include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems such as single stage, two stage, single zone, multi-zone

information includes: how, 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, maintenance logs

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

AHJ includes: ULC, CEC, National Fire Code of Canada, NBC, Local Building Codes, CSA standard M421, local fire codes

documentation includes: maintenance logs, inspection reports, as-built drawings, panel schedules, site visit log, commissioning documents, manufacturers' certification, equipment log

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
E-26.02.01L	demonstrate knowledge of ***fire alarm systems***, their applications and operation	interpret ***codes, standards and regulations*** pertaining to ***fire alarm systems***
		interpret information pertaining to ***fire alarm systems*** found on drawings and manufacturers' specifications
		identify types of ***fire alarm systems*** and describe their characteristics and applications
		identify ***fire alarm system components*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***fire alarm systems*** and ***components***
		describe types of ***associated/ancillary systems*** that interconnect with ***fire alarm systems***
E-26.02.02L	demonstrate knowledge of the procedures used to maintain ***fire alarm systems***	describe possible effects of ***fire alarm system*** maintenance on ***associated systems***

	describe the procedures used to service and maintain ***fire alarm systems*** and ***components***
	describe procedures for testing ***fire alarm systems*** and their ***components***

RANGE OF VARIABLES

fire alarm systems include: addressable (DCLA-DCLB-DCLC) and non-addressable (Class A – Class B) systems such as single stage, two stage, single zone, multi-zone

codes, standards and regulations include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC, NFC and regulations specific to AHJ

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

Essential Skills	Document Use, Reading, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-26.03.01P	identify type of ***security and surveillance system*** required for new installation	type of ***security and surveillance system*** is identified according to electrical drawings, specifications and job requirements
E-26.03.02P	remove and dispose of existing ***security and surveillance system*** when replacing	all ***security and surveillance system components*** are disposed of according to environmental standards and regulations
E-26.03.03P	determine ***security and surveillance system*** layout	***security and surveillance system*** layout is determined according to architectural and company and client requirements
E-26.03.04P	select ***security and surveillance system components***	***security and surveillance system components*** are selected according to electrical drawings, specifications, job and company and client requirements

E-26.03.05P	position, mount and assemble ***security and surveillance system components***	***security and surveillance system components*** are placed in locations according to electrical drawings, specifications, job, and company and client requirements
E-26.03.06P	terminate and interconnect ***security and surveillance system components*** and ***associated systems***	***security and surveillance system components*** and ***associated systems*** are terminated and interconnected according to electrical drawings, specifications, and job requirements
E-26.03.07P	program and configure ***security and surveillance system***	***security and surveillance system*** is programmed and configured according to job, company and client requirements, and manufacturers' specifications
E-26.03.08P	test cables	cables are tested for continuity and polarity of voice data and video data wiring ensuring cables have no opens and all ***security and surveillance system components*** are bonded to ground according to CEC
E-26.03.09P	conduct initial ***security and surveillance system*** tests	sensory and spot tests are performed, and ***security and surveillance system*** tests are performed according to electrical drawings and specifications, and AHJ
E-26.03.10P	participate in start-up and commissioning inspections	devices are activated to trigger events, system surveillance logs, notifications and alarms, and ***associated systems'*** responses according to manufacturers' and company and client specifications
E-26.03.11P	update ***documentation*** to reflect testing, inspections and maintenance performed	***documentation*** is clear, detailed and includes systems and components tested, the 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)

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 ***security and surveillance systems***, their applications and operation	interpret codes and regulations pertaining to ***security and surveillance systems***
		interpret information pertaining to ***security and surveillance systems*** found on drawings and specifications
		identify types of ***security and surveillance systems*** and describe their characteristics and applications
		describe types of ***associated systems*** that are interconnected with ***security and surveillance systems***
		identify ***security and surveillance system components*** and describe their characteristics and applications
E-26.03.02L	demonstrate knowledge of the procedures used to install, upgrade and connect ***security and surveillance systems*** and their ***components***	identify the considerations and requirements for selecting ***security and surveillance systems*** and their ***components***
		describe the procedures used to install, upgrade and connect ***security and surveillance systems*** and their ***components***
		describe procedures for testing ***security and surveillance systems*** and their ***components***
		describe the procedures for the start-up, commissioning and verification of ***security and surveillance systems***

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

Essential Skills Thinking, Reading, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-26.04.01P	obtain description of trouble of ***security and surveillance system*** from user	***information*** and ***documentation*** is obtained and description of problem is noted
E-26.04.02P	identify existing ***security and surveillance system*** and ***components***	as-built drawings and maintenance log are referenced to identify existing ***security and surveillance system*** and a walkthrough is conducted
E-26.04.03P	conduct ***security and surveillance*** system tests	tests are performed according to sensory inspections and technical inspections using ***diagnostic equipment and software***
E-26.04.04P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-26.04.05P	select replacement components	replacement components match the application
E-26.04.06P	replace defective ***security and surveillance system components***	replacement ***components*** are installed
E-26.04.07P	program and configure ***security and surveillance system***	***security and surveillance system*** is programmed and configured according to job, and company and client requirements
E-26.04.08P	clean and adjust ***components***	***components*** function according to site conditions, and company and client requirements
E-26.04.09P	update ***documentation*** to reflect testing, inspections and maintenance performed	***documentation*** is clear, detailed and includes ***systems*** and ***components*** tested, the test results and changes that were completed
E-26.04.10P	notify and explain system changes to system monitor	system changes are explained to system monitor

RANGE OF VARIABLES

security and surveillance systems include: perimeter, space, spot

information includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, changes recently made to the system, associated systems or building (painting or removing partitions)

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 ***security and surveillance systems***, their applications and operation	interpret codes and regulations pertaining to ***security and surveillance systems***
		interpret information found on drawings and specifications
		identify types of ***security and surveillance systems*** and describe their characteristics and applications
		identify ***security and surveillance system components*** and describe their characteristics and applications
		identify the considerations and requirements for selecting ***security and surveillance systems*** and their ***components***
		describe types of ***associated systems*** that interconnect with ***security and surveillance systems***
E-26.04.02L	demonstrate knowledge of the procedures used to maintain ***security and surveillance systems***	describe possible effects of ***security and surveillance system*** maintenance on ***associated systems***
		describe the procedures used to maintain ***security and surveillance systems*** and their ***components***
		describe procedures for testing ***security and surveillance systems***, their ***components*** and ***cables***
		describe the procedures for the commissioning and verification of ***security and surveillance systems***

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, data (Cat 5e, 6, 6A, 8), coaxial, twisted pairs, 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), community antenna television (CATV), public address (PA), intercom, nurse call systems, and various other industrial data communication systems.

Industrial data communication systems such as DeviceNet, Ethernet, Modbus are becoming more prevalent in the control environment for industrial electricians.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills	Reading, Thinking, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
E-27.01.01P	identify type of ***communication system*** required for new installation	type of ***communication system*** is identified according to electrical drawings, specifications, job, and company and client requirements
E-27.01.02P	remove and dispose of existing ***communication system components*** when replacing	all ***communication system components*** are disposed of according to local codes and waste disposal requirements

E-27.01.03P	determine ***communication system*** layout	***communication system*** layout is determined according to architectural, job, and company and client requirements
E-27.01.04P	select ***communication system components***	***communication system components*** are selected according to electrical drawings, specifications, job, and company and client requirements
E-27.01.05P	position, mount and assemble ***communication system components***	***communication system components*** are placed mounted and assembled in locations according to electrical drawings, manufacturers' specifications, job, and company and client requirements
E-27.01.06P	terminate and interconnect ***communication system components*** and ***associated systems***	***communication system components*** and ***associated system*** are terminated and interconnected according to electrical drawings, manufacturers' specifications, AHJ, and job requirements
E-27.01.07P	test cables for continuity, polarity, opens and grounds	voice data and video data wiring is tested ensuring cables have no opens and all ***communication system components*** are bonded to ground
E-27.01.08P	program and configure ***communication system***	***communication system*** is programmed and configured according to job, and company and client requirements, and manufacturers' specifications
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	conduct initial ***communication system*** tests	sensory and spot tests are performed, and ***communication system*** tests are performed according to electrical drawings and specifications
E-27.01.11P	participate in startup and commissioning inspections	devices are activated to trigger events such as digital system logs, notifications and alarms, and ***associated systems'*** responses
E-27.01.12P	update ***documentation***	***documentation*** is updated according to commissioning activities

RANGE OF VARIABLES

communication systems include: VDV and CATV 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), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling), Internet, industrial data communication systems such as 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

documentation includes: maintenance logs, inspection reports, as-built drawings, panel schedules, site visit log, commissioning documents, manufacturers' certification, equipment log

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
E-27.01.01L	demonstrate knowledge of ***communication systems***, their applications and operation	interpret codes, standards and regulations
		interpret information found on drawings and specifications
		identify types of ***communication systems*** and describe their characteristics and applications
		describe types of ***associated systems*** that interconnect with ***communication systems***
		identify ***communication system components*** and describe their characteristics and applications
E-27.01.02L	demonstrate knowledge of the procedures used to install, address, upgrade and connect ***communication systems*** and their ***components***	identify the considerations and requirements for selecting ***communication systems*** and their ***components***
		describe possible effects of communication system maintenance on associated systems
		describe the procedures used to install, address, upgrade and connect ***communication systems*** and their ***components***

	describe procedures for testing ***communication systems*** and their ***components***
	describe the procedures for the commissioning and verification of ***communication systems***

RANGE OF VARIABLES

communication systems include: VDV and CATV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [wireless]), PA systems (perimeter and space), intercom systems (one to one), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling)

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

E-27.02 Maintains communication systems

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-27.02.01P	obtain description of trouble of ***communication systems*** from user	malfunction issues and information are identified and documented
E-27.02.02P	identify existing ***communication systems*** and ***components***	existing ***communication systems*** and ***components*** are identified from ***documentation***
E-27.02.03P	test ***communication systems***	tests are performed according to sensory inspections and technical inspections using ***diagnostic and test equipment***
E-27.02.04P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-27.02.05P	replace ***communication system components***	replacement ***components*** are tested and verified

E-27.02.06P	update ***documentation*** to reflect testing, inspections or maintenance performed	***documentation*** is clear and detailed and includes systems and components tested, test results and changes completed and updated
E-27.02.07P	notify and explain system changes to client	client is informed of system changes

RANGE OF VARIABLES

communication systems include: VDV and CATV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [wireless]), PA systems (perimeter and space), intercom systems (one to one), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling)

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, site visit log, commissioning documents, manufacturers' certification, equipment log

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
E-27.02.01L	demonstrate knowledge of ***communication systems***, their applications and operation	interpret codes, standards and regulations pertaining to ***communication systems***
		interpret information found on drawings and specifications
		identify types of ***communication systems*** and describe their characteristics and applications
		identify ***communication system components*** and describe their characteristics and applications
		describe types of ***associated systems*** that interconnect with ***communication systems***
E-27.02.02L	demonstrate knowledge of the procedures used to maintain ***communication systems***	describe possible effects of ***communication systems*** and maintenance on ***associated systems***
		describe the procedures used to maintain ***communication systems*** and their ***components***

	describe procedures for testing ***communication systems,*** their ***components*** and cables
	describe the procedures for verification of ***communication systems***

RANGE OF VARIABLES

communication systems include: VDV and CATV systems (UTP, ScTP, data cables, fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [wireless]), PA systems (perimeter and space), intercom systems (one to one), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling), industrial data communication systems

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.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Reading, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-28.01.01P	identify type of ***building automation system*** required for new installation	type of ***building automation system*** is identified according to electrical, communication and mechanical drawings and specifications, and job, and company and client specifications
E-28.01.02P	remove and dispose of existing ***building automation system and components*** when replacing	***building automation system and components*** are disposed of according to local codes and waste disposal requirements
E-28.01.03P	determine ***building automation system*** layout	***building automation system*** layout is determined according to drawings and specifications, job, and company and client requirements, and site visit
E-28.01.04P	select ***building automation system components***	***building automation system components*** are selected according to drawings and specifications, and job, and company client requirements
E-28.01.05P	position, mount and assemble ***building automation system components***	***building automation system components*** are placed, mounted and assembled in locations according to drawings and specifications, and job, and company and client requirements

E-28.01.06P	terminate and interconnect ***building automation system components*** and ***associated systems***	***building automation system components*** and ***associated systems*** are terminated and interconnected according to drawings and specifications, and AHJ
E-28.01.07P	test ***building automation system components*** to ensure functionality	***building automation system components*** function as required
E-28.01.08P	test cables for opens and ground continuity	cables have no opens and all ***components*** are bonded to ground
E-28.01.09P	test ***building automation system***	***building automation system*** tests are performed according to drawings and specifications
E-28.01.10P	participate in startup and commissioning inspections	***building automation system components*** are activated to trigger functionality of ***building automation system*** and ***associated systems***
E-28.01.11P	update ***documentation***	***documentation*** is updated according to commissioning activities

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 such as occupancy and light levels, servers, Power over Ethernet (PoE) switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, humidity sensors, digital, analog, pressure differential, temperature, light level, occupancy and level/float sensors

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, control and data acquisition (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 ***building automation systems***, their applications and operation	interpret standards pertaining to ***building automation systems***
		interpret information pertaining to ***building automation systems*** found on drawings and specifications
		identify types of ***building automation systems*** and describe their characteristics and applications
		identify ***building automation system components*** and describe their characteristics and applications

		describe types of ***associated systems*** that interconnect with ***building automation systems***
		identify the considerations and requirements for selecting ***building automation systems*** and their ***components***
E-28.01.02L	demonstrate knowledge of the procedures used to install ***building automation systems*** and their ***components***	describe the procedures used to install ***building automation systems*** and their ***components***
		describe procedures for testing ***building automation systems*** and their ***components***
		describe the procedures for the commissioning and verification of ***building automation systems*** and their ***components***

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 such as occupancy and light levels, servers, Power over Ethernet (PoE) switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, humidity sensors, digital, analog, pressure differential, temperature, light level, occupancy and level/float sensors

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

Essential Skills Thinking, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
E-28.02.01P	obtain description of trouble of ***building automation system*** from company and client	types of ***information*** are obtained and description of problem noted
E-28.02.02P	identify ***building automation system*** and ***components***	***building automation system*** and ***components*** are identified from ***documentation***

E-28.02.03P	test ***building automation system***	***building automation system*** is tested and system activation performed
E-28.02.04P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-28.02.05P	adjust ***building automation system components***	***building automation system components*** are adjusted to optimize performance
E-28.02.06P	replace ***building automation system components***	replacement is scheduled with company and client and local monitoring station and replacement ***components*** are tested and verified
E-28.02.07P	update ***documentation***	required ***documentation*** is updated to reflect testing, inspections and maintenance performed
E-28.02.08P	notify and explain system changes	system changes are explained to system operator

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

information includes: how, where and when the problem occurred, frequency of problem, changes recently made to the system or associated systems, latest inspection report, maintenance and operation log

building automation system components include: network cabling, sensors such as occupancy and light levels, servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, humidity sensors, digital, analog, pressure differential, temperature, light level, occupancy and level/float sensors

documentation includes: maintenance logs, digital back-up logs, inspection reports, as-built drawings, panel schedules, site visit log, commissioning documents, manufacturers' specifications

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
E-28.02.01L	demonstrate knowledge of ***building automation systems***, their applications and operation	interpret ***standards*** pertaining to ***building automation systems***
		interpret information pertaining to ***building automation systems*** found on drawings and specifications
		identify types of ***building automation systems*** and describe their characteristics and applications
		identify ***building automation system components*** and describe their characteristics and applications
		describe types of ***associated systems*** that interconnect with ***building automation systems***

		identify the considerations and requirements for selecting ***building automation systems*** and their ***components***
E-28.02.02L	demonstrate knowledge of the procedures used to maintain ***building automation systems***	describe the procedures used to maintain ***building automation systems*** and their ***components***
		describe the procedures for testing ***building automation systems***, their ***components*** and ***cables***
		describe the procedures for the commissioning and verification of ***building automation systems***

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

standards include: ANSI/ASHRAE 135 (BACnet), UL 916, ANSI/TIA 862

building automation system components include: network cabling, sensors such as occupancy and light levels, servers, Power over Ethernet (PoE) switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, humidity sensors, digital, analog, pressure differential, temperature, light level, occupancy and level/float sensors

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, data, coaxial, twisted pairs, 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 and maintain these devices.

For the purpose of this standard, “install” includes both new installations and upgrading of 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

Essential Skills Document Use, Digital Technology, Reading

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-29.01.01P	select equipment	equipment is selected according to application, manufacturers’ specifications and compatible components
F-29.01.02P	visually inspect equipment to be installed	equipment to be installed is checked for damage and that nameplate data matches drawings
F-29.01.03P	locate discrete ***I/O devices***	discrete ***I/O devices*** are located by reading and interpreting prints, manufacturers’ specifications, manuals and codes
F-29.01.04P	mount discrete ***I/O devices***	discrete ***I/O devices*** are mounted using various ***methods*** and according to manufacturers’ specifications
F-29.01.05P	connect grounding, shielding and cabling	grounding, shielding and cabling are connected according to manufacturers’ and site specifications, 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 are matched to the installation requirements of external devices
F-29.01.08P	commission discrete ***I/O devices***	discrete ***I/O devices*** 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 company policy
F-29.01.10P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

input devices include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start stations

output devices include: solenoid valves, relays, indicator light

methods include: bolting, welding, threading

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-29.01.01L	demonstrate knowledge of ***discrete control devices***, their applications and operation	identify hazards and describe safe work practices pertaining to install ***discrete control devices***
		interpret information pertaining to ***discrete control devices*** found on drawings and specifications
		explain the use of discrete versus analog devices
		identify types of ***discrete control devices*** and describe their characteristics and applications
		identify discrete control device components and accessories and describe their characteristics and applications
		identify types of ***voltage used with discrete devices*** and describe their characteristics, applications and operation
		explain the use of ***discrete control devices*** for ***measurement***
		identify the considerations and requirements for selecting ***discrete control devices***, their components and accessories

F-29.01.02L	demonstrate knowledge of the procedures used to install, connect and calibrate ***discrete control devices***	describe the procedures used to install, connect and set ***discrete control devices***, their components and accessories
		describe the procedures used to calibrate ***discrete control devices***

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

Essential Skills Digital Technology, Thinking, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-29.02.01P	detect ***defects*** in discrete ***I/O device***	***defects*** in ***I/O device*** are detected by monitoring the controller
F-29.02.02P	perform sensory inspection of ***components***	***components*** are inspected for damage, wear, misalignment and loose connection
F-29.02.03P	review and analyze trends from discrete ***I/O device*** signal	trends from discrete ***I/O device*** signal are reviewed and analyzed to verify integrity of signal
F-29.02.04P	check and set power supply voltages	power supply voltages are checked and set according to plans and manufacturers' specifications
F-29.02.05P	calibrate ***discrete I/O devices***	***discrete I/O devices*** are calibrated according to drawings, manufacturers' and site specifications, and documented as found/ as left
F-29.02.06P	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-29.02.07P	verify operation of ***discrete I/O devices***	operation of ***discrete I/O device*** is verified following maintenance according to process parameters

F-29.02.08P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

defects include: corrosion, loose connection, mechanical damage, wear

input devices include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start stations

output 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 ***discrete control devices***, their applications and operation	identify hazards and describe safe work practices pertaining to ***discrete control devices***
		interpret information pertaining to ***discrete control devices*** found on drawings and specifications
		explain the use of discrete versus analog devices
		identify ***types of discrete control devices*** and describe their characteristics and applications
		identify ***discrete control device*** components and accessories and describe their characteristics and applications
		identify types of ***voltage used with discrete devices*** and describe their characteristics, applications and operation
		explain the use of ***discrete control devices*** for ***measurement***
		identify the considerations and requirements for selecting ***discrete control devices***, their components and accessories
F-29.02.02L	demonstrate knowledge of the procedures used to maintain and test ***discrete control devices***	describe the procedures used to maintain ***discrete control devices***, their components and accessories
		describe the procedures used to repair and test ***discrete control devices***, 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

Essential Skills Numeracy, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-29.03.01P	select equipment	equipment is selected according to application, manufacturers' specifications and compatible components
F-29.03.02P	visually inspect equipment to be installed	equipment to be installed is checked for damage and that nameplate data matches drawings
F-29.03.03P	locate analog ***I/O devices***	analog ***I/O devices*** are located by reading and interpreting prints, manufacturers' manuals and codes
F-29.03.04P	mount ***I/O devices***	***I/O devices*** are mounted using various ***methods*** and according to manufacturers' specifications
F-29.03.05P	connect grounding, shielding and cabling	grounding, shielding and cabling are connected according to manufacturers' and site specifications, and CEC
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 the range according to plans and manufacturers' specifications
F-29.03.08P	ensure calibration parameters for external devices	calibration parameters are matched to the 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 the 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 company policy
F-29.03.12P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

input devices include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, encoders, tachometers

output 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 ***analog control devices***, their applications and operation	identify hazards and describe safe work practices
		interpret information found on drawings and specifications
		explain the use of analog versus discrete devices
		identify ***types of analog control devices*** and describe their characteristics, applications and operation
		identify ***analog control device*** components and accessories and describe their characteristics and applications
		identify types of ***signals used with analog devices*** and describe their characteristics, applications and operation
		explain the use of ***analog control devices*** for ***measurement***
		identify the considerations and requirements for selecting ***analog control devices***, their components and accessories
F-29.03.02L	demonstrate knowledge of the procedures used to install, connect and calibrate ***analog control devices***	describe the procedures used to install, and connect ***analog control devices***, their components and accessories
		describe the procedures used to calibrate ***analog control devices***

RANGE OF VARIABLES

types of 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

Essential Skills Numeracy, Digital Technology, Document Use

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-29.04.01P	detect ***defects*** in analog ***I/O device***	***defects*** in ***I/O device*** are detected by monitoring the controller
F-29.04.02P	perform sensory inspection of ***components***	***components*** are inspected for damage, wear, misalignment and loose connection
F-29.04.03P	review and analyze trends from input device signal	trends from input device signal are reviewed and analyzed to verify integrity of signal
F-29.04.04P	calibrate analog ***I/O devices***	analog ***I/O devices*** are calibrated according to drawings, and manufacturers' and site specifications, and document as found/ as left
F-29.04.05P	verify operation of analog ***I/O devices***	operation of analog ***I/O devices*** is verified following service according to process parameters
F-29.04.06P	update maintenance log	maintenance log is updated to reflect tasks performed

RANGE OF VARIABLES

defects include: corrosion, loose connections, mechanical damage, wear

input devices include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, encoders, tachometers

output devices include: proportional valves, linear actuators, solenoid valves

components for inspection include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, proportional valves, linear actuators, solenoid valves

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-29.04.01L	demonstrate knowledge of ***analog control devices***, their applications and operation	identify hazards and describe safe work practices
		interpret information found on drawings and specifications
		explain the use of analog versus discrete devices
		identify types of ***analog control devices*** and describe their characteristics, applications and operation
		identify ***analog control device*** components and accessories and describe their characteristics and applications
		identify types of ***signals used with analog devices*** and describe their characteristics, applications and operation
		explain the use of ***analog control devices*** for ***measurement***
		identify the considerations and requirements for selecting ***analog control devices***, their components and accessories
F-29.04.02L	demonstrate knowledge of the procedures used to maintain and test ***analog control devices***	describe the procedures used to maintain ***analog control devices***, their components and accessories
		describe the procedures used to test ***analog control devices***, 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)

measurement includes: pressure, temperature, flow, level, mass, density

TASK F-30 Installs, programs and maintains automated control systems

TASK DESCRIPTOR

In industrial environments, the process requires 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 graphical user interfaces (GUI) such as HMIs. As a result, the electrical work pertaining to the input/output 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 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

Essential Skills	Document Use, Digital Technology, Thinking

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
F-30.01.01P	determine type and function of ***automated control system***	***automated control system*** is selected according to the application
F-30.01.02P	calculate conductor and cabling requirements	conductor and cable type and size are calculated to match the application, codes and manufacturers’ specifications
F-30.01.03P	position, mount and assemble ***automated control system***	***automated control system*** is placed, mounted and assembled in locations according to drawings, job, company and client requirements; is level, square, and secure, and follows building lines
F-30.01.04P	configure ***automated control systems*** hardware	***automated control system*** hardware is configured by ensuring dip switches, keying and jumpers are in required position, and by using software to configure, according to manufacturers’ specifications and drawings
F-30.01.05P	bond ***automated control systems***	***automated control systems*** are bonded based on codes and manufacturers’ specifications

F-30.01.06P	terminate conductors	conductors and cables are terminated leaving no excessive bare conductor or loose strands and is functional and connected according to the application
F-30.01.07P	set up and adjust ***automated control systems***	***automated control systems*** are operated according to application and intended function
F-30.01.08P	interconnect and configure ***automated control systems*** with ***peripheral devices***	interconnections are completed and equipment functions as intended
F-30.01.09P	test ***automated control systems*** after installation	***automated control systems*** are connected and functions according to manufacturers', company and client specifications and results are documented
F-30.01.10P	remove existing equipment when replacing and update documentation	equipment is removed with minimal impact to the environment and drawings reflect operational changes

RANGE OF VARIABLES

automated control systems include: PLC, SCADA system, DCS
peripheral devices of automated control systems include: HMI, displays, keyboard, mouse, printers

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-30.01.01L	demonstrate knowledge of ***automated control systems***, their applications and operation	identify types of ***automated control systems*** and describe their characteristics
		identify ***automated control system components*** and describe their purpose and operation
		interpret information found on drawings and specifications
		interpret codes and regulations pertaining to ***automated control systems***
		identify sources of information pertaining to automated control system installation, configuration and programming
		identify ***number*** and ***code systems*** and describe their applications
		perform conversions between ***number systems***
		explain and interpret ***control circuit logic***
F-30.01.02L	demonstrate knowledge of ***automated control system data communication systems***	identify types of ***automated control system data communication systems*** and describe their characteristics, applications and operation

		identify ***automated control system data communication system*** components and describe their characteristics, applications and operation
		identify ***methods used to communicate*** with automated control systems
F-30.01.03L	demonstrate knowledge of procedures used to install and connect ***automated control systems*** and their ***components***	describe the procedures used to install ***automated control systems*** and their ***components***
		describe the procedures used to connect ***automated control systems*** and their ***components***

RANGE OF VARIABLES

automated control systems include: PLC, SCADA system, DCS

automated control system components include: hardware (power supply, central processing unit [CPU], input/output [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

methods used to communicate with automated control systems include: handheld, computer, HMI

F-30.02 Maintains automated control systems

Essential Skills Oral Communication, Digital Technology, Thinking

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-30.02.01P	obtain description of operation and malfunction of automated control systems from user	required information about equipment operation is gathered from end user and diagnostics
F-30.02.02P	conduct ***field assessments***	source of malfunction is identified by interpreting ***diagnostic and test equipment*** results, and sensory and technical observations
F-30.02.03P	identify and remove defective components of automated control systems	defective components are removed without damage to system or other components

F-30.02.04P	repair and test malfunctioning components	components are repaired and tested according to manufacturers' specifications
F-30.02.05P	select replacement components	replacement components (OEM replacement when mandated) match the application
F-30.02.06P	install replacement components	components are installed with minimal disruptions and interruptions, and according to manufacturers' specifications and company policy
F-30.02.07P	conduct tests of automated control systems after repair	automated control system is connected and functions according to manufacturers', company and client specifications
F-30.02.08P	***inspect, clean and adjust*** components	automated control systems are restored to optimal conditions and according to manufacturers' specifications
F-30.02.09P	complete backups and document tests in maintenance log	operational problems are identified in maintenance log
F-30.02.10P	archive and update firmware	firmware is archived and updated according to manufacturers' specifications and company requirements
F-30.02.11P	compare and analyze maintenance test results	maintenance is performed when required based on analysis of test results and specifications

RANGE OF VARIABLES

field assessments include: sensory and technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters, handheld programmers, computer, network analyzer

inspect, clean and adjust include: inspecting terminations, cleaning fans and filters, adjusting cabinets and door seals, cleaning sensors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-30.02.01L	demonstrate knowledge of ***automated control systems***, their applications and operation	identify types of ***automated control systems*** and describe their characteristics, applications and operation
		identify ***automated control system components*** and describe their purpose and operation
		interpret information found on drawings and specifications
		interpret codes and regulations pertaining to ***automated control systems***

		identify sources of information pertaining to ***automated control system*** service, maintenance, troubleshoot and configuration
		identify ***number*** and ***code systems*** and describe their applications
		perform conversions between ***number systems***
		explain and interpret ***control circuit logic***
F-30.02.02L	demonstrate knowledge of ***data communication systems***	identify types of ***data communication systems*** and describe their characteristics, applications and operation
		identify automated control system data communication system components and describe their characteristics, applications and operation
		identify ***methods used to communicate*** with automated control systems
		identify ***basic instruction sets for ladder logic*** and ***basic function block***, and describe their applications
F-30.02.03L	demonstrate knowledge of procedures for maintenance of ***automated control systems***	describe the procedures used to maintain ***automated control systems*** and their ***components***
		describe basic PID control theory
		describe ***basic process control theory***

RANGE OF VARIABLES

automated control systems include: PLC, SCADA system, DCS

automated control system components include: hardware (power supply, central processing unit [CPU], input/output [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

data communication systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet

methods used to communicate with automated control systems include: handheld, 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 include: 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

Essential Skills	Digital Technology, Document Use, Thinking, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-30.03.01P	map ***inputs and outputs***	inputs and outputs are mapped using manufacturers' software to meet process requirements
F-30.03.02P	set address ***variables***	address ***variables*** 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 company policy
F-30.03.05P	set parameters for automated control program	technical and operating parameters are set as required by the installation and operation
F-30.03.06P	test and adjust automated control program	operation of system is tested and adjusted to meet design and company 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 ***automated control systems***, their applications and operation	identify automated control system ***programming languages*** and describe their applications
		explain the difference between PLC and DCS systems
F-30.03.02L	demonstrate knowledge of ***data communication systems*** for automated control systems	identify types of ***data communication systems*** and describe their characteristics, applications and operation
		compare and contrast types of ***data communication systems***

F-30.03.03L	demonstrate knowledge of procedures for programming and configuring ***automated control systems***	describe the ***procedures*** used to perform programming, editing and configuration of ***automated control systems*** online and offline
		interpret codes and regulations pertaining to ***automated control systems***
		identify ***basic instruction sets for ladder logic*** and ***basic function block*** and describe their applications
		identify ***number*** and ***code systems*** and describe their applications
		perform conversions between ***number systems***
		explain and interpret ***control circuit logic***
		describe basic PID control theory

RANGE OF VARIABLES

automated control systems include: PLC, SCADA system, DCS

automated control system components include: hardware (power supply, central processing unit [CPU], input/output [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, text based

data communication systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet

methods used to communicate with automated control systems include: handheld, 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

F-30.04 Optimizes system performance

Essential Skills	Digital Technology, Document Use, Thinking, Numeracy

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

SKILLS

	Performance Criteria	Evidence of Attainment
F-30.04.01P	ensure the version of the manufacturers' manual matches the version of the manufacturers' software	version of the manufacturers' software is matched to the manufacturers' manual
F-30.04.02P	archive and update firmware	firmware is archived and updated to facilitate system operation according to manufacturers' specifications and company requirements
F-30.04.03P	review and modify existing program and system parameters	program and system parameters are reviewed and modified to match the changes of the 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 company policy

KNOWLEDGE

	Learning Outcomes	Learning Objectives
F-30.04.01L	demonstrate knowledge of ***automated control systems***, their applications and operation	identify ***automated control system programming languages*** and describe their applications
F-30.04.02L	demonstrate knowledge of ***data communication systems*** for ***automated control systems***	identify types of ***data communication systems*** and describe their characteristics, applications and operation
F-30.04.03L	demonstrate knowledge of procedures for programming, configuring and optimizing ***automated control systems***	describe the procedures used to perform programming, editing, configuration, optimization and firmware updates of ***automated control systems*** online and offline
		interpret codes and regulations pertaining to ***automated control systems***

	identify ***basic instruction sets for ladder logic*** and ***basic function block*** and describe their applications
	identify ***number*** and ***code systems*** and describe their applications
	perform conversions between ***number systems***
	explain and interpret ***control circuit logic***
	describe basic ***PID control theory***
	describe ***basic process control theory***

RANGE OF VARIABLES

automated control systems include: PLC, SCADA system, DCS
automated control system components include: hardware (power supply, central processing unit [CPU], input/output [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
data communication systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet
methods used to communicate with automated control systems include: handheld, computer, HMI
basic instruction sets for ladder logic include: Normally Open (NO), Normally Closed (NC), output
basic function block include: 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 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

Essential Skills Numeracy, Thinking, Document Use

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
yes	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	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, company policy and manufacturers’ recommendations
F-31.01.02P	connect system ***components***	system ***components*** are connected according to plans, codes and process requirements
F-31.01.03P	calibrate pneumatic control ***devices***	pneumatic control ***devices*** are calibrated to process requirements
F-31.01.04P	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-31.01.05P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

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 ***pneumatic control systems***, their ***components*** and operation	interpret information pertaining to ***pneumatic control systems*** devices found on drawings and specifications
		identify types of ***pneumatic control systems*** and describe their applications
		interpret ***documentation*** to determine the operation of pneumatic control systems
F-31.01.02L	demonstrate knowledge of pneumatic related calculations	perform pneumatic related ***calculations***
F-31.01.03L	demonstrate knowledge of the procedures used to install ***pneumatic control system equipment*** and components	describe the procedures used to install ***pneumatic control systems*** and their components

RANGE OF VARIABLES

pneumatic control systems include: instrument air, instrument gas

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

Essential Skills Numeracy, Thinking, Document Use

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

	SKILLS	
	Performance Criteria	**Evidence of Attainment**
F-31.02.01P	test and verify control devices	control devices are tested and verified according to ***system specifications***
F-31.02.02P	calibrate and adjust control devices	control devices are calibrated and adjusted according to system specifications and maintenance schedules
F-31.02.03P	change system ***components and materials***	system ***components and materials*** are changed according to manufacturers' specifications and company policy

F-31.02.04P	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 user, and using maintenance documentation and historical data
F-31.02.05P	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-31.02.06P	lock out and de-energize the energy potential	lockout and de-energization are confirmed by performing a post-operational test to confirm zero energy state
F-31.02.07P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures
F-31.02.08P	verify operation	operation is verified before returning to service
F-31.02.09P	document changes	changes are documented according to company policy

RANGE OF VARIABLES

system specifications include: pressure, flow
components and materials include: filters, drying systems, reservoirs, compressors

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-31.02.01L	demonstrate knowledge of ***pneumatic control systems***, their components and operation	interpret information found on drawings and specifications
		identify types of ***pneumatic control systems*** and describe their applications
		interpret ***documentation*** to determine the operation of pneumatic control systems
F-31.02.02L	demonstrate knowledge of pneumatic related calculations	perform pneumatic related ***calculations***
F-31.02.03L	demonstrate knowledge of the procedures used to maintain pneumatic control system equipment and components	describe the procedures used to maintain ***pneumatic control systems*** 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

Essential Skills	Thinking, Document Use, Reading

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
no	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	NV	ND

SKILLS

	Performance Criteria	Evidence of Attainment
F-31.03.01P	select ***control devices*** and ***components***	***control devices*** and ***components*** are selected according to manufacturers' specifications, process requirements and codes
F-31.03.02P	determine location of ***control devices***	location of ***control devices*** is determined according to codes and practices, and manufacturers' recommendations
F-31.03.03P	connect ***control devices*** and ***components***	***control devices*** and ***components*** are connected using materials
F-31.03.04P	verify operation of hydraulic equipment and ***control devices***	operation of hydraulic equipment and ***control devices*** are verified to ensure they are within specified parameters by using test equipment and procedures
F-31.03.05P	update documentation	documentation is updated to reflect changes carried out

RANGE OF VARIABLES

control devices include: solenoids, switches, gauges, actuators

components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, thermometers, fluids

KNOWLEDGE

	Learning Outcomes	Learning Objectives
F-31.03.01L	demonstrate knowledge of hydraulic control systems, their components and operation	interpret information found on drawings and specifications
		identify types of hydraulic control systems and describe their applications
		interpret ***documentation*** to determine the operation of hydraulic control systems
F-31.03.02L	demonstrate knowledge of the procedures used to install hydraulic control system equipment and ***components***	describe the procedures used to install hydraulic control systems and their ***components***

RANGE OF VARIABLES

documentation includes: schematics, manufacturers' manuals

components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, thermometers, fluids

F-31.04 Maintains hydraulic control systems

Essential Skills Reading, Thinking, Document Use

NL	NS	PE	NB	QC	ON	MB	SK	AB	BC	NT	YT	NU
no	yes	yes	yes	NV	yes	yes	ND	ND	yes	ND	NV	ND

SKILLS

	Performance Criteria	Evidence of Attainment
F-31.04.01P	test and verify ***control devices*** and ***components***	***control devices*** and ***components*** are tested and verified according to ***system specifications***
F-31.04.02P	calibrate and adjust ***control devices*** and ***components***	***control devices*** and ***components*** are calibrated and adjusted according to system specifications and maintenance schedules
F-31.04.03P	check fluid and filters	fluids and filters are checked according to manufacturers' specifications
F-31.04.04P	change system ***components***	system ***components*** are changed according to manufacturers' specifications and company policy
F-31.04.05P	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-31.04.06P	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-31.04.07P	lock out and de-energize the energy potential	lockout and de-energization are confirmed by performing a post-operational test to confirm zero energy state
F-31.04.08P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures

F-31.04.09P	verify operation	operation is verified before returning to service
F-31.04.10P	update maintenance log	maintenance log is updated to reflect tasks performed

RANGE OF VARIABLES

control devices include: solenoids, switches, gauges, actuators

system specifications include: pressure, flow, temperature, level

components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, thermometers

	KNOWLEDGE	
	Learning Outcomes	**Learning Objectives**
F-31.04.01L	demonstrate knowledge of hydraulic control systems, their ***components*** and operation	interpret information pertaining to hydraulic control systems devices found on drawings and specifications
		interpret ***documentation*** to determine the operation of hydraulic control systems
F-31.04.02L	demonstrate knowledge of the procedures used to maintain hydraulic control system equipment and ***components***	describe the procedures used to maintain hydraulic control systems and their ***components***

RANGE OF VARIABLES

documentation includes: schematics, manufacturers' manuals

components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, thermometers

APPENDIX A
ACRONYMS

AC	alternating current
AED	automated external defibrillator
AFCI	arc fault circuit interrupter
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
AVR	Automatic Voltage Regulator
ASCII	American Standard Code for Information Interchange
BAC	Building Automation and Control
BCD	binary coded decimal
BICSI	Building Industry Consulting Services International
BIL	Basic Insulation Level
CAD	computer-aided design
CAM	computer-aided manufacturing
CATV	community antenna television
CEC	Canadian Electrical Code
CFC	chlorofluorocarbon
CMMS	computerized maintenance management systems
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
DMM	digital multimeter
DVR	digital video recorder
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
HMI	human machine interfacing
HID	high intensity discharge
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
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
PLC	programmable logic controller
PoE	power over Ethernet
PID	proportional-integral-derivative
PPE	personal protective equipment
VT	voltage transformer (previously called potential transformer)
PVC	Poly Vinyl Chloride
RFID	radio frequency identification
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Data Sheets
ScTP	screened twisted pair
SIS	safety instrumented systems
SPL	sound pressure level
SI	système internationale
TDG	Transportation of Dangerous Goods
TDR	time-domain reflectometer
TIA	Telecommunications Industry Association
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
WHMIS	Workplace Hazardous Materials Information System
WLL	working load limit

APPENDIX B
TOOLS AND EQUIPMENT

Hand Tools

adjustable wrenches
cable tie gun
cable splice/stripper tool
calculator
chisels
coaxial stripper and crimper
crimping pliers
drill bits
files
fish tape
flashlight
fuse puller
grounding tools/temporary protective grounds
hack saw
hammers
hex keys (metric/imperial or SAE)
hole saws
jumpers
knives
knock-out cutters
linesman pliers
needle nose pliers
nut drivers (metric/imperial or SAE)
picks
pipe benders
pipe threaders
pullers
punches
scraper
screwdrivers
screw starter
scribe
semi-conductor extactor
side cutters
slide lock pliers
socket sets (metric/imperial or SAE)
spline keys
static discharge wristbands and anti-static mats
step drill
taps (metric/imperial or SAE) and dies
tape measures
telescopic magnet
telescopic mirror
torch (butane, propane, oxy-acetylene)
trouble light
voice data crimp tools
voice data punch down tools
wire strippers
wrenches (metric/imperial or SAE)

Portable Power Tools

circular saw
cut-off saw
drill
grinder
hammer drill
jig saw
magnetic base drill press
power pipe bender
pipe threading machine
PVC bender

Portable Power Tools (*continued*)

heat gun
hydraulic crimper
hydraulic knock-out punch
impact gun
reciprocating saw
soldering equipment
wire puller

Powder-Actuated Tools

exothermic welding equipment
powder-actuated fastening tool

Stationary Power Tools

band saw
bearing heater
belt sander
bench grinder
buffer
chop saw
drill press
grinder
hydraulic power unit
hydraulic press
parts washer
sand blaster
threading machine
under cutting machine

Fibre Optic Tools

cleaver
inspection scope
optical time-domain reflectometer (OTDR)
polishing pucks
power meter and light source
swivel/fuse

Electrical Test and Diagnostic Equipment

chart recorder
circuit tracer
clamp ammeter
conductivity tester
contact resistance meter
frequency meter
Geiger counter
ground fault finder
hi-pot tester
instrumentation loop calibrator
insulation resistance tester (megohmmeter/megger)
laptop computer and software
lumen meter (testing light)
multimeter
network analysers
non-contact voltage tester
optical power meter and light source
optical time domain reflectometer (OTDR)
oscilloscope
phase sequence tester
potential tester
pressure calibration pump
signal generator
sound meter
temperature gun
thermal graphic camera
thermal graphic equipment
time domain reflectometer (TDR)
timer
voltage tester
Wheatstone bridge

Mechanical Measuring Equipment

alignment tools
dial indicators
distance measuring wheel
feeler gauges
hydrometer
micrometers
pressure gauges
protractor
tachometer
torque wrenches
vernier calipers
vibration sensor (accelerometer, velocity, proximity)

Rigging, Tugging, Hoisting, Lifting Material

articulated boom lift
beam clamps
block and tackle
cable puller (hand or electric powered)
cable pulling grips (wire mesh grips)
chain fall/come-along
hoists
lifting eyes
platform lift
pulley
ropes
scissor lift
shackles
slings
strain relief
tow motor/fork lift

Scaffolding and Access Equipment

aerial man lift
extension ladder
man baskets
platform lift
portable stairs
scaffolds
scissor lift
step ladder

Personal Protective Equipment and Safety Equipment

air pack
arc flash PPE
dust mask
ear protectors
face shield
fall arrest equipment
fall restraint equipment
fire retardant clothing
gas detectors
grounding stick
hard hat
harness
high visibility vests
high voltage gloves (insulated)
high voltage test equipment
hot gloves
hot pad
hot stick
knee pads
low voltage gloves (insulated)
protective apron
protective gloves/gauntlets
respirator
S.C.B.A. (Self-Contained Breathing Apparatus)
safety footwear
safety glasses/goggles
welding gloves

APPENDIX C
GLOSSARY

arc flash	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 size of the conductors
bonding	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
cable	a complete manufactured assembly of one or more insulated conductors which may also include optical fibres, fillers, strength members, insulating and protective material, having a continuous overall covering providing electrical, mechanical and environmental protection to the assembly
cathodic protection	protection technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell
dip switches	a group of miniature switches
commissioning	initial startup of new equipment systematically to OEM specifications
extra low voltage	any voltage up to and including 30 volts, as per CEC
grounding	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
high voltage	any voltage exceeding 750 volts, as per CEC
low voltage	any voltage exceeding 30 volts but not exceeding 750 volts, as per CEC
raceway	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 tubing (EMT and ENT) underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters
unit equipment	a piece of equipment with its own storage battery, charging means, transfer switch, lamps or output terminals, test switch and indicators