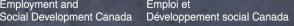


Red Seal Occupational Standard Industrial Electrician



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Red Seal Occupational Standard

Industrial Electrician



Title: Industrial Electrician

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PDF

Cat. No.: Em15-3/7-2021E-PDF ISBN: 978-0-660-40622-0

ESDC

Cat. No.: LM-491-12-21E

Foreword

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

Background

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

Standards have the following objectives:

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

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

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

Acknowledgements

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

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

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

Structure of the Occupational Standard

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

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

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

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

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

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

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

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

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

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

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

Task Descriptor: a general description of the task

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

Skills:

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

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

Knowledge:

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

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

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

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

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

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

Methodology

Development of the Standard

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

Harmonization of Apprenticeship Training

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

Online Survey

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

Draft Review

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

Validation and Weighting

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

MWA Each jurisdiction assigns a percentage of questions to each MWA for an examination

that would cover the entire trade.

TaskS Each jurisdiction assigns a percentage of exam questions to each task within a MWA.

SUB-TaskS Each jurisdiction indicates, with a YES or NO, whether or not each sub-task is

performed by skilled workers within the occupation in its jurisdiction.

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

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

Definitions for Validation and Weighting

YES sub-task performed by qualified workers in the occupation in that province or

territory

NO sub-task not performed by qualified workers in the occupation in that province or

territory

NV standard Not Validated by that province or territory

ND trade Not Designated in a province or territory

NOT COMMON sub-task, task or MWA performed less than 70% of responding jurisdictions; these

CORE (NCC) will not be tested by the Interprovincial Red Seal Examination for the trade

NATIONAL average percentage of questions assigned to each MWA and task in Interprovincial

AVERAGE % Red Seal Examination for the trade

Provincial/Territorial Abbreviations

NL Newfoundland and Labrador

NS Nova Scotia

PE Prince Edward Island

NB New Brunswick

QC Quebec
ON Ontario
MB Manitoba

SK Saskatchewan

AB Alberta

BC British Columbia
NT Northwest Territories

YT Yukon Territory

NU Nunavut

Description of the Industrial Electrician Trade

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

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

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

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

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

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

Trends in the Industrial Electrician Trade

Technology

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

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

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

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

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

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

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

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

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

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

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

Safety and environmental considerations

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

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

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

Essential Skills Summary

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

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

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

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, coordinating 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.

Industry Expected Performance

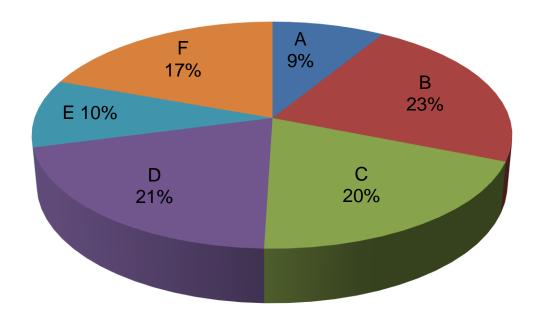
All tasks must be performed according to the applicable jurisdictional codes and standards. All health and safety standards must be respected and observed. Work should be done efficiently and at a high quality without material waste or environmental harm. All requirements of employers, engineers, designers,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

Language Requirements

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

Pie Chart

of Red Seal Examination Weightings



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

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

Industrial Electrician

Task Matrix and Weightings

A - Performs common occupational skills

9%

Task A-1 Performs safety-related functions 22%	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 18%	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 18%	A-3.01 Interprets plans, drawings and specifications	A-3.02 Identifies hazardous installations	3.03 Organizes materials and supplies
	A-3.04 Plans project tasks and procedures	A-3.05 Prepares specific location in facility	A-3.06 Finalizes required documentation
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 21%	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, transmission, distribution and service systems

23%

Task B-7 Installs and maintains utility and non- utility supply services and metering equipment	B-7.01 Installs single-phase utility and non-utility supply services and metering equipment	B-7.02 Maintains single- phase utility and non-utility supply services and metering equipment	B-7.03 Installs three-phase utility and non-utility supply services and metering equipment
	B-7.04 Maintains three-phase utility and non-utility supply services and metering equipment		
Task B-8 Installs and maintains protection devices 16%	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 14%	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 protection and detection systems 12%	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 protection and detection systems	B-11.06 Maintains ground- fault protection and detection systems

			-
Task B-12 Installs and maintains power generating and conversion systems 9%	B-12.01 Installs alternating current (AC) generating systems	B-12.02 Maintains alternating current (AC) generating systems	B-12.03 Installs direct current (DC) generating and conversion systems
	B-12.04 Maintains direct current (DC) generating and conversion systems		
Task B-13 Installs and maintains renewable energy generating and energy storage systems 6%	B-13.01 Installs renewable energy generating and energy storage systems	B-13.02 Maintains renewable energy generating and energy storage systems	
Task B-14 Installs and maintains high-voltage systems 10%	B-14.01 Installs high-voltage systems	B-14.02 Maintains high- voltage systems	
Task B-15 Installs and maintains transformers 12%	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	

Task C-16 Installs and maintains raceways, cables, conductors and enclosures 26%	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 14%	C-18.01 Connects power to heating, ventilation and air- conditioning (HVAC) systems and associated equipment	C-18.02 Installs heating, ventilation and air- conditioning (HVAC) controls	C-18.03 Maintains heating, ventilation and air- conditioning (HVAC) electrical components
Task C-19 Installs and maintains electric heating systems and controls 15%	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 12%	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 other fixed equipment and control systems

21%

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

E - Installs and maintains signalling and communication systems

10%

Task E-26
Installs and maintains signalling
systems
35%

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

Task E-28 Installs and maintains building automation systems

E-27.01 Installs communication systems	E-27.02 Maintains communication systems
E-28.01 Installs building automation systems	E-28.02 Maintains building automation systems

Task F-29 Installs and maintains input/output (I/O) devices 48%	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 15%	F-31.01 Installs pneumatic control systems	F-31.02 Maintains pneumatic control systems	F-31.03 Installs hydraulic control systems
	F-31.04 Maintains hydraulic control systems		

Harmonization of Apprenticeship Training

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

1. Trade name

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

2. Number of Levels of Apprenticeship

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

3. Total Training Hours During Apprenticeship Training

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

4. Sequencing Topics and Related Sub-tasks

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

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

Safety-Related Functions 1.01 Maintains safe work environment

equipment (PPE) and safety equipment 1.03 Performs lock-out and tag-out procedures 1.04 Identifies environmental conditions

1.02 Uses personal protective

Level 2 Level 3 Level 4

Tools and Equipment

2.01 Uses common and specialty tools and equipment 2.02 Uses access equipment 2.03 Uses rigging, hoisting and lifting equipment

Organizes Work

3.01 Interprets plans, drawings and specifications 3.02 Identifies hazardous installations 3.03 Organizes materials and supplies 3.04 Plans project tasks and procedures 3.05 Prepares specific location in facility 3.06 Finalizes required documentation

Support Components

4.01 Fabricates support structures 4.02 Installs brackets, hangers and fasteners 4.03 Installs selsmic restraint systems

Electrical Systems (Commissions and Decommissions)

5.01 Commissions systems 5.02 Performs shutdown and startup procedures 5.03 Decommissions systems

Communication Techniques

6.01 Uses communication techniques

Utility and non-Utility/Supply Services and Metering Equipment

7.01 Installs single-phase utility and non-utility/supply services and metering equipment
7.02 Maintains single-phase utility and non-utility/supply services and metering equipment

Mentoring Techniques

6.02 Uses mentoring techniques

Utility and non-Utility/Supply Services and Metering Equipment

7.03 Installs three-phase utility and non-utility/supply services and metering equipment 7.04 Maintains three-phase utility and non-utility/supply services and metering equipment

Level 1 Level 2 Level 3 Level 4

Protection Devices

8.01 Installs overcurrent protection devices 8.02 Maintains overcurrent protection devices 8.03 installs ground fault, arc fault and surge protection devices 8.04 Maintains ground fault. arc fault and surge protection devices 8.05 Installs under-and-over voltage protection devices 8.06 Maintains under-andover voltage protection devices

Low-Voltage Distribution

9.01 installs low-voltage distribution equipment 9.02 Maintains low-voltage distribution equipment

Low-Voltage Distribution

9.01 installs low-voltage distribution equipment 9.02 Maintains low-voltage distribution equipment

> **Power Conditioning Systems** 10.01 installs power conditioning systems 10.02 Maintains power conditioning systems

Bonding and Grounding and Ground-Fault Protection and Detection Systems

11.01 installs grounding systems 11.03 installs bonding systems

Bonding and Grounding and Ground-Fault Protection and

11.01 installs grounding systems 11.02 Maintains grounding systems

11.03 Installs bonding systems 11.04 Maintains bonding

systems 11.05 installs ground-fault protection and detection

Power Generating and

systems

12.03 installs direct current (DC) generating and conversion systems 12.04 Maintains DC generating and conversion systems

Bonding and Grounding and Ground-Fault Protection and Detection Systems

11.01 Installs grounding systems 11.02 Maintains grounding systems

11.03 Installs bonding systems 11.04 Maintains bonding systems

11.05 Installs ground-fault protection and detection systems

Power Generating and Conversion Systems

12.01 Installs alternating current (AC) generating systems 12.02 Maintains AC generating systems

Bonding and Grounding and Ground-Fault Protection and Detection Systems

11.06 Maintains ground-fault protection and detection systems

Level 1 Level 2 Level 3 Level 4

Renewable Energy Generating and Energy

13.01 installs renewable energy generating and energy storage systems 13.02 Maintains renewable energy generating and energy storage systems

Renewable Energy Generating and Energy Storage Systems

13.01 Installs renewable energy generating and energy storage systems 13.02 Maintains renewable energy generating and energy storage systems

High-Voltage Systems

14.01 installs high-voltage systems 14.02 Maintains high-voltage systems

15.01 installs extra-low voltage transformers 15.02 Maintains extra-low voltage transformers 15.03 installs low voltage single-phase transformers 15.04 Maintains low voltage single-phase transformers

Transformers

15.05 Installs low voltage three-phase transformers 15.06 Maintains low voltage three-phase transformers 15.07 installs high voltage transformers. 15.08 Maintains high voltage transformers

Raceways, Cables, Conductors and Enclosures

16.01 installs conductors and cables **16.02 Maintains conductors** and cables 16.03 installs conduit, tubing and fittings 16.04 Installs raceways 16.05 installs boxes and enclosures 16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures

16.01 installs conductors and cables **16.02 Maintains conductors** and cables 16.03 installs conduit, tubing and fittings 16.04 installs raceways 16.05 installs boxes and enclosures 16.06 Maintains conduit, tubing, fittings, raceways, boxes and enclosures

17.01 installs luminaires **17.02 Maintains luminaires** 17.03 installs wiring devices 17.04 Maintains wiring devices

Branch Circuitry and

17.01 installs luminaires **17.02 Maintains luminaires** 17.03 Installs wiring devices 17.04 Maintains wiring devices

Branch Circuitry and Devices

17.01 installs luminaires **17.02 Maintains luminaires** 17.03 installs wiring devices 17.04 Maintains wiring devices

18.01 Connects power to HVAC systems and associated equipment 18.02 Installs HVAC controls **18.03 Maintains HVAC** electrical components

Level 1 Level 2 Level 3 Level 4

Electric Heating Systems

19.01 Installs electric heating systems and controls 19.02 Maintains electric heating systems and controls

Exit and Emergency Lighting Systems

20.01 Installs exit and emergency lighting systems 20.02 Maintains exit and emergency lighting systems

Cathodic Protection Systems

21.01 Installs cathodic protection systems 21.02 Maintains cathodic protection systems

Motors, Starters and Control

22.01 Installs motor starters
22.02 Maintains motor
starters
22.03 Installs motor control
devices
22.04 Maintains motor
control devices

Motors, Starters and Control Devices

22.01 Installs motor starters 22.02 Maintains motor starters 22.03 Installs motor control devices 22.04 Maintains motor control devices

Orlyes

23.01 Installs AC drives
23.02 Maintains AC drives
23.03 Installs DC drives
23.04 Maintains DC drives

Other Fixed Equipment and Associated Controls 24.01 installs other fixed

equipment and associated controls
24.02 Maintains other fixed equipment and associated controls

Motors

25.05 Installs DC motors 25.06 Maintains DC motors

Motors

25.01 Installs single-phase motors
25.02 Maintains single-phase motors
25.03 Installs three-phase motors
25.04 Maintains three-phase motors
25.05 Installs DC motors
25.06 Maintains DC motors

Motors

25.01 Installs single-phase motors
25.02 Maintains single-phase motors
25.03 Installs three-phase motors
25.04 Maintains three-phase motors
25.05 Installs DC motors.
25.06 Maintains DC motors

Communication Systems

27.01 installs communications systems 27.02 Maintains communication systems

Signalling Systems
26.01 Installs fire alarm
systems
26.02 Maintains fire alarm
systems
26.03 Installs security and
surveillance systems

surveillance systems

Communication Systems

26.04 Maintains security and

27.02 Maintains communication systems

Building Automation Systems

28.01 Installs building automation systems 28.02 Maintains building automation systems

Input/Output (I/O) Devices

29.01 Installs discrete Input/output (I/O) devices 29.02 Maintains discrete Input/output (I/O) devices 29.03 Installs analog Input/output (I/O) devices 29.04 Maintains analog Input/output (I/O) devices

Automated Control Systems

30.01 Installs automated control systems
30.02 Maintains automated control systems
30.03 Programs automated control systems
30.04 Optimizes system performance

Pneumatic and Hydraulic Control Systems

31.01 Installs pneumatic control systems
31.02 Maintains pneumatic control systems
31.03 Installs hydraulic control systems
31.04 Maintains hydraulic control systems

Major Work Activity A

Performs common occupational skills

Task A-1 Performs safety-related functions

Task Descriptor

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

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

A-1.01 Maintains safe work environment

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

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

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

Range of Variables

hazards include: arc flash, arc blast, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation, open holes, confined space, fire, tripping hazards, overhead work, heights, SF₆ gas

barriers and **signage** include: caution and danger tapes, fences, tags, signs, barricades **safety components** include: first aid kits, fire extinguishers, safety data sheets (SDS), emergency eye wash stations, automated external defibrillator (AED), confined space rescue equipment **designated substances** include: acrylonitrile, arsenic, asbestos, benzene, coke oven emissions, ethylene oxide, isocyanates, lead, mercury, silica, vinyl chloride, SF₆ gas, H₂S gas

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

Range of Variables

hazards include: arc flash, arc blast, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation, open holes, confined space, fire, tripping hazards, overhead work, heights, SF₆ gas

emergency situations include: explosions, fire, hazardous product release *designated substances* include: acrylonitrile, arsenic, asbestos, benzene, coke oven emissions, ethylene oxide, isocyanates, lead, mercury, silica, vinyl chloride

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

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

	Sk	tills
	Performance Criteria	Evidence of Attainment
A-1.02.01P	identify <i>facility hazards</i> and regulations requiring use of <i>PPE</i> and <i>safety equipment</i>	facility hazards and regulations are determined according to facility visits and by performing a pre-job analysis
A-1.02.02P	select <i>PPE</i> and <i>safety equipment</i>	PPE and safety equipment are selected according to tasks, facility hazards, OH&S and facility policies
A-1.02.03P	replace or tag and remove from service damaged or faulty PPE and safety equipment	PPE and safety equipment are inspected for wear, damage or defect prior to use, and damaged or faulty PPE and safety equipment are replaced or tagged and removed from service
A-1.02.04P	ensure fit of <i>PPE</i>	PPE are adjusted to ensure fit according to manufacturers' specifications
A-1.02.05P	apply safety regulations and standards	safety regulations and standards are applied according to facility and AHJ requirements
A-1.02.06P	organize, clean and store <i>PPE</i> and <i>safety equipment</i>	PPE and safety equipment are organized, cleaned and stored according to facility 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

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

PPE includes: see Appendix B

safety equipment includes: see Appendix B

safety regulations and standards include: WHMIS, AHJ, CSA safety standards, facility safety policy,

general/prime contractor policies

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

Range of Variables

PPE includes: see Appendix B

safety equipment includes: see Appendix B

applications include: hazardous locations, height, confined space

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

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

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

A-1.03.05P	test for zero energy state	system is tested for zero energy state using testing 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 according to OH&S and facility policies

Range of Variables

approved devices include: breaker lock, multi-lock, lock box, lock tag, arc flash protection equipment energy includes: electrical, mechanical, hydraulic, pneumatic, chemical, radiation, thermal, compressed air energy sources, energy stored in springs, potential energy from suspended parts (gravity) testing equipment includes: permanently mounted absence of voltage tester, voltmeters, temporary protective ground equipment, high-voltage testers, pressure gauges, voltage sticks (hot sticks)

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

Range of Variables

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

n

A-1.04 Identifies environmental conditions

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

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

Range of Variables

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

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

Range of Variables

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

Task A-2 Uses tools and equipment

Task Descriptor

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

A-2.01 Uses common and specialty tools and equipment

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

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

Range of Variables

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

components include: batteries (primary and rechargeable), cords, attachment plugs **accessories** include: threading dies, batteries, bending shoes, chucks, tool bits

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

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

A-2.02 Uses access equipment

NL	NS	PE	NB	QC	ON	MB	SK	AB	ВС	NT	ΥT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

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

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

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

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

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

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

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

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

regulatory requirements include: inspection documentation, training, certification

A-2.03 Uses rigging, hoisting and lifting equipment

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

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

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

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

	Knowledge					
	Learning Outcomes	Learning Objectives				
A-2.03.01L	demonstrate knowledge of hoisting, lifting and rigging equipment, their applications, limitations and procedures for use	identify types of rigging equipment and accessories, and describe their applications, limitations and procedures for use				
		identify types of hoisting and lifting equipment and accessories, and describe their applications, limitations and procedures for use				
		identify potential hazards , and describe safe work practices pertaining to hoisting, lifting and rigging equipment				
		describe procedures to inspect, maintain and store hoisting, lifting and rigging equipment				
A-2.03.02L	demonstrate knowledge of <i>regulatory requirements</i> pertaining to hoisting, lifting and rigging equipment	identify and interpret codes and regulations pertaining to hoisting, lifting and rigging equipment				
A-2.03.03L	demonstrate knowledge of basic hoisting and lifting operations	identify types of knots, hitches, splices and bends, and describe their applications and procedures to tie them				
		describe <i>considerations</i> when rigging material or equipment for lifting				
		identify and describe procedures 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 specific location in facility, confined spaces, open trenches, uneven surfaces, weather conditions

regulatory requirements include: inspection documentation, training, certification **considerations** include: load characteristics, working load limit (WLL), equipment and accessories, environmental factors, anchor points, sling angles

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

Task A-3 Organizes work

Task Descriptor

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

A-3.01 Interprets plans, drawings and specifications

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

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

Range of Variables

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

scaling includes: metric, imperial, custom

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

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

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

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

A-3.02 Identifies hazardous installations

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

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

Range of Variables

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

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

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

A-3.03 Organizes materials and supplies

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

	Skills					
	Performance Criteria	Evidence of Attainment				
A-3.03.01P	identify and select <i>materials</i> and supplies	materials and supplies are selected according to drawings, specifications, and CSA, WHMIS 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 <i>materials</i> and supplies	materials and supplies are loaded, unloaded and stored according to related factors				
A-3.03.04P	identify required <i>materials</i> and <i>supplies</i>	materials and supplies are identified by performing material take-off according to drawings and specifications				
A-3.03.05P	coordinate receiving of <i>materials</i> and <i>supplies</i>	materials and supplies are received according to established schedule				

A-3.03.06P	verify shipments for quality and quantity of <i>materials</i> and <i>supplies</i>	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, documented and stored in secured area

materials include: wires and cables, luminaires, panelboards, starters and contactors, transformers, distribution equipment, fittings, raceways, support hardware, wire connectors, fasteners
 supplies (consumables) include: pulling compounds, tape, thread compounds
 criteria include: storage availability, shelf life, product availability, delivery and site schedules
 factors include: installation sequence, job specifications, site conditions, SDS, type of material

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

Range of Variables

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

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

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

considerations include: available space, schedule, storage location

A-3.04 Plans project tasks and procedures

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

		Skills
	Performance Criteria	Evidence of Attainment
A-3.04.01P	determine job requirements	job requirements are determined according to specific location in facility, schedule and documentation
A-3.04.02P	determine labour and equipment requirements	labour and equipment requirements are determined according to <i>job</i> 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 <i>requirements</i>
A-3.04.05P	draw and sketch layouts	layouts are determined according to installation task at hand

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

job specifications include: CEC, conductor sizes, load requirements, locations *criteria* include: inclement weather, product availability, project progression, critical path, project management tools

requirements include: shutdown and installation sequencing, worker qualifications

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

Range of Variables

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

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

A-3.05 Prepares specific location in facility

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

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

Range of Variables

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

locates include: underground services and utilities, concealed building elements

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

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

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

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

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

A-3.06 Finalizes required documentation

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

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

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

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

personnel include: other shift, supervisor, production staff

revisions include: as-builts, redline changes

	Knov	wledge
	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 an additional support where required.

A-4.01 Fabricates support structures

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

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

Range of Variables

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

materials include: wood, steel, aluminum

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

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

	Knov	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 <i>materials</i> , their characteristics and application				
		identify <i>fasteners</i> , their characteristics and application				
A-4.01.02L	demonstrate knowledge of procedures to fabricate support structures	identify <i>tools and equipment</i> used to fabricate support structures, and describe their applications and procedures for use				
		describe procedures to fabricate support structures				

materials include: wood, steel, aluminum

fasteners include: screws, straps, inserts, nuts, bolts, anchors, wedge clamps, seismic restraints tools and equipment include: measuring equipment, saws, drills, clamps, welding equipment

A-4.02 Installs brackets, hangers and fasteners

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

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

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

hangers include: trapezes, pipe clamps, beam clamps

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

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

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

Range of Variables

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

hangers include: trapezes, pipe clamps, beam clamps

fasteners include: spring nuts, bolts, screws, concrete anchors building materials include: steel, concrete, brick, block, wood

A-4.03 Installs seismic restraint systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
A-4.03.01P	select and fabricate seismic restraint systems	seismic restraint systems are selected and fabricated according to job specifications and jurisdictional regulations			
A-4.03.02P	select tools and equipment	tools and equipment are selected according to task			
A-4.03.03P	determine installation location	installation location is determined and obstructions are avoided			
A-4.03.04P	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, thimbles, rods, wire rope clamps, shock mounts **obstructions** include: duct work, plumbing pipes, structural building elements, equipment

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

Range of Variables

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

Task A-5 Commissions and decommissions electrical systems

Task Descriptor

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

A-5.01 Commissions systems

1	٧L	NS	PE	NB	QC	ON	MB	SK	AB	ВС	NT	YT	NU
у	es	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

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

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

potential includes: electrical, kinetic, mechanical, ionizing radiation, thermal, hydraulic, pneumatic, gravity problems include: wrong direction of rotation, out of specification rotation speed, alarm tripping, equipment malfunction, foreign material left in equipment, voltage regulation, current regulation, temperature regulation, direction of laser and ultrasonic beams, status indicators system components include: detection systems, status and alarm systems, inputs, outputs operational checks include: current, winding temperature, phase rotation, voltage, protection settings, drives parameters, Proportional, Integral, Derivative (PID) loop tuning, safety circuits documentation includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications

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

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

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

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

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

A-5.02 Performs shutdown and startup procedures

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

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

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

system equipment includes: control equipment, power distribution equipment

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

documentation includes: AHJ reports, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, design and manufacturers' specifications, standard operating procedures **connected components** include: limit switches, I/O cards, safety devices, push buttons, pressure and temperature sensors, printed circuit boards

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

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

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

A-5.03 Decommissions systems

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

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

Range of Variables

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

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

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

facility documentation includes: O&M manuals, single line diagrams, schematics, panel schedules, asbuilt drawings, procedure manuals, equipment programming

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

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

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

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

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

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

Task A-6 Uses communication and mentoring techniques

Task Descriptor

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

A-6.01 Uses communication techniques

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

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

Range of Variables

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

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

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

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

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

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

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

harassment: as defined by the Canadian and jurisdictional Human Rights Commissions **discrimination**: as defined by the Canadian Human Rights Act and jurisdictional human rights laws **electronic messages** include: email, text messages

A-6.02 Uses mentoring techniques

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

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

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

steps required to demonstrate a skill include: understanding the who, what, where, when, why, and how, explaining, showing, giving encouragement, following up to ensure skill is performed correctly practice conditions means: guided, limited independence, full independence harassment: as defined by the Canadian and jurisdictional Human Rights Commissions discrimination: as defined by the Canadian Human Rights Act and jurisdictional human rights laws

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

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

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

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

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

strategies to assist in learning a skill include: understanding the basic principles of instruction,

developing coaching skills, being mature and patient, providing feedback

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

Major Work Activity B

Installs and maintains generating, transmission, distribution and service systems

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

Task Descriptor

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

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

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

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

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

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

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

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

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

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

services include: overhead, underground, temporary

service components include: supports, enclosures, raceways, conduit, meter sockets, panels, service

entrance equipment, service mast, point of attachment **service conductors** include: wire, cables, conductors

supply authority includes: local utility, electrical inspectors

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

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

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

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

	Knowledge					
	Learning Outcomes	Learning Objectives				
B-7.01.01L	demonstrate knowledge of 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 <i>supply authority</i> 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 considerations and requirements for selecting type of <i>single-phase</i> services, service components and service conductors				

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

single-phase services include: temporary service, overhead, underground, single and multiple metering **service components** include: supports, enclosures, raceways, conduit, panels, service mast, point of attachment

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

fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints **metering equipment** includes: meter sockets, CTs, PTs, enclosures, meter mounting equipment, associated secondary wiring

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

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

B-7.03

Installs utility and non-utility three-phase supply services and metering equipment

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

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

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

services include: overhead, underground, temporary

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

service conductors include: wire, cables, conductors

supply authority includes: local supply authority, electrical inspectors

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

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

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

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

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

three-phase services include: temporary service, overhead, underground, single and multiple metering *service components* include: metering equipment, supports, enclosures, raceways, conduits, panels, switchgear, service entrance equipment, service mast, point of attachment

service conductors include: wire, cables, conductors

fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints **metering equipment** includes: meter sockets, CTs, VTs, enclosures, meter mounting equipment, associated secondary wiring

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

Task B-8 Installs and maintains protection devices

Task Descriptor

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

Industrial electricians maintain overcurrent, ground fault, arc fault, surge protection devices and under/over voltage devices by troubleshooting, diagnosing faults, replacing devices and repairing them. They also perform maintenance on these devices to ensure they are in good operating condition. Industrial electricians may also be responsible for maintaining and updating coordination studies (selective or non-selective coordination) for the distribution systems.

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

B-8.01 Installs overcurrent protection devices

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

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

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

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 characteristics, applications and operation	identify types of overcurrent protection devices , and describe their characteristics and applications						
		interpret information pertaining to overcurrent protection devices found on drawings and specifications						
		explain purpose and operation of overcurrent protection devices						
		explain effects of short-circuit current and describe associated damage to circuit						
		interpret codes and regulations pertaining to overcurrent protection devices						
		identify considerations and requirements for selecting <i>overcurrent protection devices</i>						
		explain purpose of coordination studies						
		explain purpose of updating documentation						

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

overcurrent protection devices include: fuses, breakers, relay protection
documentation includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

B-8.02 Maintains overcurrent protection devices

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

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

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

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

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

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

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

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

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

hardware includes: bolts, screws, brackets, stand-offs, cabling, transition pieces, boxes, enclosures *documentation* includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

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

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

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

surge protection devices include: MOV, zener diodes, thyristors, surge suppressors, lightning arrestors **documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings

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

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

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

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

diagnostic and test equipment includes: multimeters, voltage testers, ammeters, power quality analyzers, thermographic imaging devices, insulation resistance testers, non-contact infrared sensors information includes: where and when problem occurred, has problem happened before, is it intermittent or consistent in nature, have any changes recently been made to the system, associated systems or building (painting or removing partitions), latest inspection report, log books, manufacturers' manuals, standard operating procedures

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

field assessments include: sensory inspections, technical inspections

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

describe procedure to maintain <i>arc fault</i> protection devices
describe procedure to maintain surge protection devices

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

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

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

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

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

Range of Variables

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

hardware includes: bolts, screws, brackets, stand-offs, cabling, transition pieces, boxes, enclosures *documentation* includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

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

under- and over-voltage protection devices include: protective relays, sensors, VTs *documentation* includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

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

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

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

under- and over-voltage protection devices include: protective relays, sensors, VTs
 documentation includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, terminal identification

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

Task Descriptor

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

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

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

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

B-9.01 Installs low-voltage distribution equipment

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

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

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

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

enclosures include: CSA enclosures, enclosures for hazardous locations

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

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

describe procedures to install <i>low-</i> voltage power distribution equipment
describe procedures to connect low- voltage power distribution equipment
describe procedures for transporting and moving electrical equipment

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

considerations include: load, voltage ratings, required circuit capacity, available fault currents **enclosures** include: CSA enclosures, enclosures for hazardous locations

B-9.02 Maintains low-voltage distribution equipment

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

Range of Variables

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

Task B-10 Installs and maintains power conditioning systems

Task Descriptor

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

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

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

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

B-10.01 Installs power conditioning systems

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

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

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

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

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

fasteners include: screws, bolts, straps, inserts, anchors, wedge clamps, seismic restraints **documentation** includes: as-builts, schematics, panel schedules, log sheets, drive drawings, shop drawings, maintenance logs, terminal identification

	Knowledge					
	Learning Outcomes	Learning Objectives				
B-10.01.01L demonstrate knowledge of power conditioning and UPS systems, and applications		interpret codes and regulations pertaining to power conditioning and UPS systems				
		explain power quality and its impact on equipment operation				
		explain single-phase and three-phase power factor correction, and its associated calculations				
		identify types of 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				

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

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

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

B-10.02 Maintains power conditioning systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

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

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

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

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

surge suppression equipment includes: capacitors, shunt coils and diodes

Task B-11 Installs and maintains bonding, grounding and groundfault protection and detection systems

Task Descriptor

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

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

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

B-11.01 Installs grounding systems

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

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

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

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

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

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

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

B-11.02 Maintains grounding systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

Range of Variables

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

B-11.03 Installs bonding systems

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

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

Range of Variables

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

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

B-11.04 Maintains bonding systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

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

B-11.05 Installs ground-fault protection and detection systems

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

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

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

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

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

Range of Variables

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

B-11.06 Maintains ground-fault protection and detection systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

Range of Variables

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

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

Task Descriptor

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

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

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

B-12.01 Installs alternating current (AC) generating systems

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

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

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

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

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

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

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

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

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

B-12.02 Maintains AC generating systems

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

prime mover DC generators include: series, shunt, compound

B-12.04 Maintains DC generating and conversion systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections, infrared inspection *diagnostic and test equipment* includes: multimeters, voltage testers, ammeters, hi-pot testers, thermographic imaging devices, insulation resistance testers, ground loop testers

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

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

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

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

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

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

Task Descriptor

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

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

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

B-13.01 Installs renewable energy generating and energy storage systems

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

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

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

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

renewable energy generating system connections include: grid dependent, grid independent (standalone)

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

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

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

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

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

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

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

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

renewable energy generating system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters, isolation disconnects, protection devices **energy storage system** includes: pumped hydro, compressed air energy storage, batteries (various technologies)

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

B-13.02 Maintains renewable energy generating and energy storage systems

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

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

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

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

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

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

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

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

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

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

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

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

Task B-14 Installs and maintains high-voltage systems

Task Descriptor

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

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

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

B-14.01 Installs high-voltage systems

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

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

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

high-voltage equipment includes: distribution equipment, contactors, motor starters, transformers, MCCs, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs, isolating and load breaking switches, transmission, breakers, protection devices, worker protective grounds, hot sticks non-current carrying metallic components include: fences, towers, doors, enclosures, buildings testing equipment includes: ground loop impedance tester, megohmmeter, proximity tester, phasing sticks, relay test sets

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

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

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

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

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

high-voltage equipment includes: distribution equipment, contactors, motor starters, transformers, MCCs, capacitors, reactors, switches, disconnects, rectifiers, reclosers, VTs, CTs, isolating and load breaking switches, transmission, breakers, protection devices, worker protective grounds, hot sticks documentation includes: as-builts, schematics (AC, DC), shop drawings, single-line drawings hazards include: corona discharge, ozone gas, proximity to energized exposed equipment commissioning tests include: polarity, ground grid resistance, hi-pot, phasing, functionality, timing, current injection, interlocking, ultrasonic detectors, thermographic imaging device

B-14.02 Maintains high-voltage systems

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

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

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

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

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

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

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

hazardous insulating mediums include: SF₆, polychlorinated biphenyl (PCB) *field assessments* include: sensory inspections, technical inspections

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

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

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

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

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

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

hazards include: corona discharge, ozone gas, proximity to energized exposed equipment *temporary protective ground equipment* includes: ground clamps and straps, conductors, switchgear ground truck

Task B-15 Installs and maintains transformers

Task Descriptor

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

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

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

B-15.01 Installs extra-low-voltage transformers

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

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

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

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

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

Range of Variables

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

B-15.02 Maintains extra-low-voltage transformers

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

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

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

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

field assessments include: sensory inspections, technical inspections

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

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

cleaning procedures include: removing contaminants

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

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

Range of Variables

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

B-15.03 Installs low-voltage single-phase transformers

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

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

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

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

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

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

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

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

describe procedures to install <i>low- voltage single-phase transformers</i>
describe procedures to install <i>low-</i> voltage single-phase transformers in parallel

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

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

B-15.04 Maintains low-voltage single-phase transformers

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

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

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

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

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

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

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

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

low-voltage single-phase transformer components include: casings and enclosures, core, primary and secondary windings, dielectric liquid, cooling fans, on-line/off-line manual and automatic tap changers **cleaning and adjustment** includes: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, vacuuming and cleaning windings

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

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

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

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

B-15.05 Installs low-voltage three-phase transformers

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

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

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

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

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

tests include: insulation test, voltage test, polarity test, turn ratio test, thermographic test **documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

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

describe procedures to install <i>low- voltage three-phase transformers</i> in parallel
describe procedures to install <i>low-</i> voltage three-phase transformers using various winding configurations

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

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

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

B-15.06 Maintains low-voltage three-phase transformers

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

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

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

diagnostic and test equipment includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, phase rotation meters, insulation resistance testers, ground loop testers cleaning and adjustment procedures include: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, checking external metal case (including external latching system to prevent contamination and access), vacuuming and cleaning windings

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

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

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

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

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

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

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

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

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

B-15.07 Installs high-voltage transformers

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

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

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

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

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

tests include: insulation test, voltage test, hi-pot test, oil analysis test, turn ratio test, thermographic test **documentation** includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

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

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

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

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

B-15.08 Maintains high-voltage transformers

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

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

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

diagnostic and test equipment includes: multimeters, power quality analyzers, hi-pot testers, thermographic imaging devices, insulation resistance testers, ground loop tester, proximity tester cleaning and adjustment procedures include: inspecting terminations, cleaning/replacing filters, cleaning cooling fans, external metal case (including external latching system to prevent contamination and access), cleaning insulators

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

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

field assessments include: sensory inspections, technical inspections, oil sampling *documentation* includes: schematic diagrams and drawings, maintenance schedules, single line diagrams, as-built drawings, manufacturers' specifications

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

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

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

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

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

Major Work Activity C

Installs and maintains wiring systems

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

Task Descriptor

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

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

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

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

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

C-16.01 Installs conductors and cables

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

	Skills				
	Performance Criteria	Evidence of Attainment			
C-16.01.01P	determine <i>installation requirements</i> , and select conductors, cables and <i>components</i>	size, type and number of conductors, cables and <i>components</i> are selected, identified and colour-coded according to drawings, specifications, and AHJ, CSA and CEC requirements			
C-16.01.02P	select tools and equipment	tools and equipment are selected according to task			
C-16.01.03P	measure and cut conductors and cables	cables and conductors are measured and cut to allow for final routing and sufficient length for terminations according to CEC requirements			

C-16.01.04P	install conductors, cables and components	conductors, cables and <i>components</i> are installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.05P	assemble <i>components</i>	components are assembled and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.06P	prepare conductors and cables for termination	conductors and cables are cleaned and prepared for termination according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.01.08P	complete documentation to reflect changes	all changes to new and updated installations are documented
C-16.01.09P	determine requirements for removal of existing conductors, cables and <i>components</i>	removal of existing conductors, cables and <i>components</i> requirements are determined according to facility requirements and considering impact removal will have on facility
C-16.01.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
C-16.01.11P	remove conductors, cables, and components, and update documentation	conductors, cables, and <i>components</i> are removed according to electrical specifications and AHJ requirements, and remaining installations are supported, terminated and left in a safe and secure state according to CSA and CEC requirements, and documentation updated

installation requirements include: purpose of cable or conductor, tools and equipment required for installation, installation environment in locations such as hazardous, wet, underground (direct buried or in raceway), outdoor, classes, categories, zones (divisions), type of termination

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

	Knowledge			
	Learning Outcomes	Learning Objectives		
C-16.01.01L	demonstrate knowledge of conductors, cables and their <i>components</i>	identify terminology associated with conductors, cables and their <i>components</i>		
		identify types of conductors, cables and their <i>components</i> , 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
		identify considerations and requirements for selecting conductors, cables and their <i>components</i>
		identify considerations and requirements for removal of conductors, cables and their <i>components</i>
C-16.01.02L	demonstrate knowledge of procedures to remove and install conductors, cables and their <i>components</i>	identify tools and equipment used to remove and install conductors, cables and their <i>components</i> , and describe their applications and procedures for use
		describe procedures to remove conductors, cables and their <i>components</i>
		describe procedures to prepare and install conductors, cables and their <i>components</i>
		describe procedures to terminate conductors and cables

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

C-16.02 Maintains conductors and cables

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

	Sk	cills
	Performance Criteria	Evidence of Attainment
C-16.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented
C-16.02.02P	select tools and equipment	tools and equipment are selected according to task
C-16.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results
C-16.02.04P	determine type and location of fault	type and location of fault is determined according to <i>field assessments</i>

C-16.02.05P	repair or replace malfunctioning component	malfunctioning component is repaired or replaced and tested, and system is returned to original condition
C-16.02.06P	label repaired conductors and corresponding terminals	repaired conductors and corresponding terminals are labelled according to drawings and specifications
C-16.02.07P	inspect terminations and test conductors for excessive heating	terminations are inspected according to manufacturers' specifications and test results documented

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

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

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

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

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

	Knov	vledge
	Learning Outcomes	Learning Objectives
C-16.02.01L	demonstrate knowledge of conductors, cables and their <i>components</i>	identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause faults in specific types of conductors, cables and their <i>components</i>
		interpret information pertaining to conductors and cables found on manufacturers' specifications and previous records
		interpret codes, standards and regulations pertaining to conductors and cables
		identify <i>considerations</i> when maintaining conductors, cables and their <i>components</i>
C-16.02.02L	demonstrate knowledge of procedures to maintain conductors, cables and their <i>components</i>	identify tools and equipment used to maintain conductors, cables and their <i>components</i> , and describe their applications and procedures for use
		describe <i>procedures</i> to maintain conductors, cables and their <i>components</i>

components include: mechanical fittings, compression fittings, supports, straps, connectors, hangers, heat shrink, anti-oxidant compounds, non-ferrous and/or non-conductive plates, connectors
 considerations include: integrity of insulation, integrity of terminations, odours, colour, physical protection, supports, movement due to temperature or vibration

procedures include: thermographic surveys, multimeter testing, megohmmeter testing (resistance testing), hi-pot testing, sensory testing (visual, smell and touch)

C-16.03 Installs conduit, tubing and fittings

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

	S	kills
	Performance Criteria	Evidence of Attainment
C-16.03.01P	determine <i>installation requirements</i> , and select conduit, tubing and fittings	size and <i>type</i> of conduit, tubing and fittings are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.02P	determine routing of conduit and tubing	routing of conduit and tubing is practical for application and takes into consideration other trades and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.03P	select tools and equipment	tools and equipment are selected according to task
C-16.03.04P	measure, cut, thread and bend conduit and tubing	conduit and tubing are measured, cut, threaded and bent according to routing, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.05P	assemble, position, mount and support conduit, tubing and fittings	conduit, tubing and fittings are assembled, positioned, mounted and supported without damage, and according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.03.06P	determine requirements for removal of existing conduit, tubing and fittings	removal requirements are determined according to facility requirements and considering impact removal will have on facility
C-16.03.07P	remove conduit, tubing and fittings, and update documentation	conduit, tubing and fittings are removed, and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

installation requirements include: purpose of conduit, tubing and fitting, tools and equipment required for installation, installation environment in locations such as hazardous, wet, underground, outdoor, classes, categories and zones (divisions), combustible and non-combustible installations **types** include: rigid metal, rigid Poly Vinyl Chloride (PVC), high-density polyethylene (HDPE) conduit, electrical metallic tubing (EMT), liquid-tight flex, coated rigid metal, non-metallic flex **tools and equipment** include: PVC benders, PVC cutters, heat guns, pipe benders, pipe threading

machines, power pipe benders, equipment for specialized conduit systems

	Knov	vledge			
	Learning Outcomes	Learning Objectives			
C-16.03.01L	demonstrate knowledge of conduit, tubing, <i>fittings and components</i> , their characteristics and applications	identify types of conduit, tubing, <i>fittings</i> and components, and describe their characteristics, applications and limitations			
		interpret information pertaining to conduit, tubing, <i>fittings and components</i> found on drawings and specifications			
		interpret codes and regulations pertaining to conduit, tubing, <i>fittings and components</i>			
		identify considerations and requirements for removal of conduit, tubing, <i>fittings</i> and components			
		identify considerations of other trades within same project			
C-16.03.02L	demonstrate knowledge of procedures to remove and install conduit, tubing, fittings and components	identify tools and equipment used to remove and install conduit, tubing, fittings and components, and describe their applications and procedures for use			
		describe procedures to cut, thread and bend conduit and tubing			
		describe procedures to install and support conduit, tubing, <i>fittings and components</i>			
		describe procedures used for removal of conduit, tubing, <i>fittings and components</i>			

Range of Variables

fittings and components include: mechanical fittings, rain-tight fittings, EYS, supports, straps, connectors, couplings, reducers, bushings, LB, LR, LL, Tee, close nipple, chase nipple, terminal adapters, offset, 90 degrees, 45 degrees, long and short sweeps, PVC cement, expansion joints, lock nuts, unions

tools and equipment include: PVC benders, PVC cutters, heat guns, pipe benders, pipe threading machines, power pipe benders, equipment for specialized conduit systems

C-16.04 Installs raceways

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

	Sk	ills
	Performance Criteria	Evidence of Attainment
C-16.04.01P	determine <i>installation requirements</i> and select raceways	size and type of <i>raceway</i> are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.02P	determine routing of <i>raceway</i>	routing of <i>raceway</i> is practical for application and takes into consideration other trades and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.03P	select tools and equipment	tools and equipment are selected according to task
C-16.04.04P	measure and cut <i>raceways</i> , and select fittings	raceways are measured and cut, and fittings are selected according to routing, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.05P	assemble <i>raceways</i> and fittings into position, and mount and support <i>raceways</i>	raceways and fittings are assembled into position, and raceways are mounted and supported without damage and according to application, drawings, specifications, and AHJ, CSA and CEC requirements
C-16.04.06P	determine requirements for removal of existing <i>raceways</i>	removal requirements when performing an upgrade are determined according to facility requirements, and considering impact removal will have on facility
C-16.04.07P	remove <i>raceways</i> and <i>raceway components</i> and update documentation	raceways and raceway components are removed according to electrical specifications and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

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

raceways include: cable tray, ladder tray, wire trays, underfloor raceways, busways, cellular raceways, surface raceways

raceways do not include: conduit and tubing as these are covered in sub-task 16.03

raceway components include: fittings (couplings and connectors), supports, expansion joints, floor/junction boxes

	Knov	vledge
	Learning Outcomes	Learning Objectives
C-16.04.01L	demonstrate knowledge of <i>raceways</i> , <i>raceway components</i> , their characteristics and applications	identify types of <i>raceways</i> and <i>raceway components</i> , and describe their characteristics, applications and limitations
		interpret codes, standards and regulations pertaining to <i>raceways</i>
		interpret information pertaining to raceways found on drawings and specifications
		identify considerations and requirements for selecting <i>raceways</i> and <i>raceway components</i>
		identify considerations and requirements for removal of <i>raceways</i> and <i>raceway components</i>
		identify considerations of other trades within same project
C-16.04.02L	demonstrate knowledge of procedures to remove, install and support <i>raceways</i>	identify tools and equipment used to remove, install and support <i>raceways</i> , and describe their applications and procedures for use
		describe procedures to install and support raceways and raceway components
		describe procedures to remove <i>raceways</i> and <i>raceway components</i>

Range of Variables

raceways in this sub-task include: cable tray, ladder tray, wire trays, underfloor raceways, busways, cellular raceways, surface raceways

raceways in this sub-task do not include: conduit and tubing as these are covered in sub-task 16.03 *raceway components* include: fittings (couplings and connectors), supports, expansion joints, floor/junction boxes

C-16.05 Installs boxes and enclosures

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

	Sk	tills
	Performance Criteria	Evidence of Attainment
C-16.05.01P	determine <i>installation requirements</i> and select boxes and <i>enclosures</i>	size and type of boxes and enclosures are selected according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.02P	determine installation location for boxes and enclosures	location for box and <i>enclosures</i> is practical for application, takes into consideration other trades, and is according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.03P	select tools and equipment	tools and equipment are selected according to task
C-16.05.04P	position and mount boxes and enclosures	boxes and enclosures are positioned and mounted without damage to meet requirements of application and according to drawings, specifications, and AHJ, CSA and CEC requirements
C-16.05.05P	determine requirements for removal of existing boxes and <i>enclosures</i>	removal requirements for existing boxes and <i>enclosures</i> are determined according to facility requirements and considering impact removal will have on facility
C-16.05.06P	remove boxes and enclosures and update documentation	boxes and enclosures are removed and remaining installations are supported and terminated according to drawings, specifications, and AHJ, CSA and CEC requirements, and documentation updated

Range of Variables

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

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

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-16.05.01L	demonstrate knowledge of boxes and enclosures, their characteristics and applications	identify types of boxes and enclosures , and describe their characteristics, applications and limitations					
		interpret codes, standards and regulations pertaining to boxes and <i>enclosures</i>					
		interpret information pertaining to boxes and <i>enclosures</i> found on drawings and specifications					
		identify <i>considerations</i> and requirements for selecting boxes and <i>enclosures</i>					
		identify <i>considerations</i> and requirements for removal of boxes and <i>enclosures</i>					
		identify <i>considerations</i> of other trades within same project					
C-16.05.02L	demonstrate knowledge of procedures to maintain <i>enclosures</i>	identify tools and equipment used to maintain <i>enclosures</i> , and describe their applications and procedures for use					
		describe procedures to determine placement and to mount boxes and enclosures					
		describe procedures to remove boxes and enclosures					

enclosures do not include: enclosure types for specific active electrical control equipment such as rotating equipment, transformers, panelboards, motor starters and other fixed control equipment considerations include: materials, volume, dimensions, positioning, mass/weight, environment, accessibility, size of raceway or cable entering box or enclosure, CSA types (NEMA), Ingress Protection (IP) types

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

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

	Skills							
	Performance Criteria	Evidence of Attainment						
C-16.06.01P	conduct <i>inspections</i>	inspections of conduit, tubing, fittings, raceways, boxes, enclosures and associated components are completed, and results documented						
C-16.06.02P	select tools and equipment	tools and equipment are selected according to task						
C-16.06.03P	clean conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>	conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i> are cleaned according to housekeeping standards, and facility and AHJ requirements						
C-16.06.04P	locate and determine type of malfunction	location and type of malfunction is identified according to <i>inspections</i>						
C-16.06.05P	repair or replace damaged conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>	damaged conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i> are repaired or replaced according to AHJ, CSA and CEC requirements						
C-16.06.06P	tighten or adjust loose <i>components</i>	components are tightened or adjusted according to AHJ, CSA and CEC requirements						

Range of Variables

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

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-16.06.01L	demonstrate knowledge of conduit, tubing, fittings, raceways, boxes, and their <i>components</i>	identify environmental conditions, hazards, incidents, situations and inside/outside conditions that can cause damage in specific types of conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>					
		interpret codes, standards and regulations pertaining to conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>					

		identify <i>considerations</i> when maintaining conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>
C-16.06.02L	demonstrate knowledge of procedures to maintain conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>	identify tools and equipment used to maintain conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i> , and describe their applications and procedures for use
		describe procedures to repair or replace conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>
		describe procedures to tighten or adjust conduit, tubing, fittings, raceways, boxes, enclosures and their components
		describe procedures to clean conduit, tubing, fittings, raceways, boxes, enclosures and their <i>components</i>

components include: supports, expansion joints, straps, connectors, couplings, screws, bolts, locknuts **considerations** include: corrosion, condition of supports, tightness and presence of mounting screws, tightness of locknuts, physical damage, cleanliness

Task C-17 Installs and maintains branch circuitry and devices

Task Descriptor

Various devices and luminaires are installed to meet the power and lighting requirements of the facility sources. Branch circuitry components are installed in a manner which makes the power safe and convenient to use. Branch circuitry is used to conduct the power from the overcurrent device to the load. Lighting systems are used to illuminate specified areas according to consumer needs. Lighting controls operate light functions, adjust lighting levels and optimize efficiency. Industrial electricians install and maintain branch circuitry.

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

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

C-17.01 Installs luminaires

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

	Skills						
	Performance Criteria	Evidence of Attainment					
C-17.01.01P	determine type of <i>luminaire installation</i> requirements	size and type of <i>luminaire</i> are selected for application according to job, facility and CEC requirements					
C-17.01.02P	determine type of <i>lamps</i> and <i>installation</i> requirements	size and type of <i>lamps</i> are selected for application according to manufacturers' specifications and facility requirements					
C-17.01.03P	calculate branch circuit requirements	calculations are completed based on voltage and amperage requirements and according to CEC requirements					
C-17.01.04P	determine installation location for luminaire	luminaire locations are determined according to drawings, specifications, facility requirements, codes and design criteria for luminaire					
C-17.01.05P	select tools and equipment	tools and equipment are selected according to task					
C-17.01.06P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and CEC requirements					
C-17.01.07P	mount <i>luminaire</i>	Iuminaire is mounted and supported according to drawings, specifications, facility and CEC requirements, and other codes					

C-17.01.08P	install branch circuit wiring	branch circuit wiring is installed and identified according to drawings, specifications and CEC requirements, and without damage to insulation and without stress
C-17.01.09P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-17.01.10P	test for required operation	operation is verified by testing operation and lighting levels
C-17.01.11P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
C-17.01.12P	determine requirements for removal of luminaires	requirements for removal of <i>luminaires</i> are determined according to facility requirements and considering impact removal will have on facility
C-17.01.13P	remove existing <i>luminaires</i>	existing <i>luminaires</i> are removed and remaining installations are left in a safe condition according to facility, AHJ, CSA and CEC requirements
C-17.01.14P	update documentation	documentation is updated to reflect changes
C-17.01.15P	dispose of or recycle <i>lamps</i> , ballasts, and enclosures	lamps, ballasts and enclosures are disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements

luminaires include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed *lamps* include: high intensity discharge (HID), light emitting diode (LED), incandescent, fluorescent, ultraviolet, infrared

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

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-17.01.01L	demonstrate knowledge of <i>luminaires</i> and <i>lamps</i> , their characteristics, applications and operation	identify types of <i>luminaires</i> and <i>lamps</i> , and describe their characteristics, applications and operation					
		identify luminaire and lamp components, and describe their characteristics and applications					
		interpret codes, standards and regulations pertaining to <i>luminaires</i> and <i>lamps</i>					

		interpret information pertaining to <i>luminaires</i> and <i>lamps</i> found on drawings and specifications
		identify considerations and requirements for removal of <i>luminaires, lamps</i> and their components
		identify considerations and requirements for selecting <i>luminaires</i> and <i>lamps</i> , and their components
C-17.01.02L	demonstrate knowledge of procedures to remove, install, dispose of or recycle and support <i>luminaires</i> and <i>lamps</i>	identify tools and equipment used to remove, install, dispose of or recycle and support <i>luminaires</i> and <i>lamps</i> , and describe their applications and procedures for use
		describe procedures to remove <i>luminaires</i> and <i>lamps</i> , and their components
		describe procedures to retrofit <i>luminaires</i> and their components
		describe procedures to install and support <i>luminaires</i> and their components
		describe procedures to perform tests related to <i>luminaires</i> and <i>lamps</i>
		describe procedures for disposal of or recycling of <i>luminaires</i> and <i>lamps</i> , and their components

luminaires include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed *lamps* include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

C-17.02 Maintains luminaires

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

		Skills				
	Performance Criteria	Evidence of Attainment				
C-17.02.01P	clean <i>luminaires</i> and <i>lamps</i>	<i>luminaires</i> and <i>lamps</i> are cleaned according to facility requirements and environmental conditions				
C-17.02.02P	select tools and equipment	tools and equipment are selected according to task				

C-17.02.03P	determine source of malfunction	source of malfunction is determined according to <i>facility sources</i> observation or complaint, <i>field assessments</i> , and <i>diagnostic and test equipment</i> results
C-17.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
C-17.02.05P	select replacement components	OEM or equivalent replacement components are selected
C-17.02.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions
C-17.02.07P	conduct tests of branch circuitry, <i>luminaires</i> and <i>lamps</i>	branch circuitry, <i>luminaires</i> and <i>lamps</i> are tested after repair and scheduled maintenance, connected and function according to manufacturers' specifications and codes
C-17.02.08P	update documentation	documentation is updated to reflect changes

luminaires include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed *lamps* include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

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

field assessments include: sensory inspections, technical inspections

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

	Knowledge							
	Learning Outcomes	Learning Objectives						
C-17.02.01L	demonstrate knowledge of branch circuitry, <i>luminaires</i> and <i>lamps</i> , their components, characteristics, applications and operation	identify types of branch circuitry, <i>luminaires</i> and <i>lamps</i> , and their components, and describe their characteristics, applications and operation						
C-17.02.02L	demonstrate knowledge of procedures to maintain branch circuitry, <i>luminaires</i> and <i>lamps</i> , and their components	identify tools and equipment used to maintain branch circuitry, <i>luminaires</i> and <i>lamps</i> , and their components, and describe their applications and procedures for use						
		describe procedures to maintain branch circuitry, <i>luminaires</i> and <i>lamps</i> , and their components						

luminaires include: pole mounted, wall mounted, ceiling mounted, pendant, surface, recessed *lamps* include: HID, LED, incandescent, fluorescent, ultraviolet, infrared

C-17.03 Installs wiring devices

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

	Skills						
	Performance Criteria	Evidence of Attainment					
C-17.03.01P	determine type of wiring devices required and installation requirements	type of wiring devices and their installation requirements are selected according to drawings, specifications, and CEC and facility requirements					
C-17.03.02P	determine installation location for <i>wiring</i> devices	wiring devices locations are determined according to drawings, specifications, and CEC and facility requirements					
C-17.03.03P	select tools and equipment	tools and equipment are selected according to task					
C-17.03.04P	select wiring devices	wiring devices are selected according to drawings, specifications and CEC requirements					
C-17.03.05P	install wiring	wiring is installed and identified according to drawings, specifications and CEC requirements, and without damage to insulation and without stress					
C-17.03.06P	mount wiring devices	wiring devices are mounted according to manufacturers' specifications and CEC requirements					
C-17.03.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ and CEC requirements					
C-17.03.08P	test for required operation	operation is verified by testing circuit for specified voltage and phasing					
C-17.03.09P	select and install cover plate	cover plate is selected and installed according to facility requirements and codes					
C-17.03.10P	determine requirements for removal of wiring devices	removal requirements are determined according to facility requirements and considering impact removal will have on facility					

C-17.03.11P	remove existing wiring devices	wiring devices are removed and remaining installations are left in a safe condition according to AHJ and CEC requirements
C-17.03.12P	update documentation	documentation is updated to reflect changes

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

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

	Knowledge							
	Learning Outcomes	Learning Objectives						
C-17.03.01L	demonstrate knowledge of <i>wiring devices</i> , their characteristics, applications and operation	identify types of <i>wiring devices</i> , and describe their characteristics, applications and operation						
		interpret codes, standards and regulations pertaining to <i>wiring devices</i>						
		interpret information pertaining to wiring devices found on drawings and specifications						
		identify considerations and requirements for removal of <i>wiring devices</i>						
		identify considerations and requirements for selecting <i>wiring devices</i>						
C-17.03.02L	demonstrate knowledge of procedures to remove and install wiring devices	identify tools and equipment used to remove and install <i>wiring devices</i> , and describe their applications and procedures for use						
		describe procedures to remove and install wiring devices						

Range of Variables

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

C-17.04 Maintains wiring devices

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

	Skills							
	Performance Criteria	Evidence of Attainment						
C-17.04.01P	determine source of malfunction	source of malfunction is determined according to <i>facility sources</i> , <i>field assessments</i> , and <i>diagnostic and test equipment</i> results						
C-17.04.02P	select tools and equipment	tools and equipment are selected according to task						
C-17.04.03P	identify and remove defective components	defective components are removed without damage to system or other components						
C-17.04.04P	select replacement components	OEM or equivalent replacement components are selected						
C-17.04.05P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions						
C-17.04.06P	conduct tests of branch circuitry and wiring devices	branch circuitry and wiring devices are tested after repair, connected and function according to manufacturers' specifications and CEC requirements						
C-17.04.07P	update documentation	documentation is updated to reflect changes						

Range of Variables

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

field assessments include: sensory inspections, technical inspectionsdiagnostic and test equipment includes: multimeters, thermographic imaging deviceswiring 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 <i>wiring devices</i> , their components, characteristics, applications and operation	identify types of branch circuitry and wiring devices, and their components, and describe their characteristics, applications and operation					
C-17.04.02L	demonstrate knowledge of procedures to maintain branch circuitry and <i>wiring devices</i> , and their components	identify tools and equipment used to maintain branch circuitry and wiring devices, and their components, and describe their applications and procedures for use					
		describe procedures to maintain branch circuitry and wiring devices, and their components					

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

Task C-18 Installs and maintains heating, ventilation and airconditioning (HVAC) electrical components

Task Descriptor

Heating, ventilation and cooling systems (in this task, that is, systems where electricity is not the sole source of energy) are typically installed by other trades but are electrically connected by industrial electricians. Industrial electricians connect power to HVAC systems, HVAC associated equipment and controls. They also install HVAC system controls as well as repair or replace HVAC components, controls and associated equipment.

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

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

C-18.01 Connects power to HVAC systems and associated equipment

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

	Skills						
	Performance Criteria	Evidence of Attainment					
C-18.01.01P	determine connected load requirements	connected load requirements are determined by interpreting nameplate ratings, and according to drawings, specifications, and AHJ, CSA and CEC requirements					
C-18.01.02P	select feeder or branch circuit wiring, disconnect means and overcurrent protection devices	feeders or branch circuit wiring, disconnect means and overcurrent protection devices are selected according to drawings, specifications, and AHJ, CSA and CEC requirements					
C-18.01.03P	select tools and equipment	tools and equipment are selected according to task					
C-18.01.04P	install feeder or branch circuit wiring,	branch circuit wiring conductors, are identified, selected and installed without damage to insulation and without stress according to drawings, specifications, and CEC requirements					
C-18.01.05P	install disconnect means and overcurrent protection devices	disconnect means and overcurrent protection devices are identified, selected and installed according to drawings, specifications, and CEC requirements					

C-18.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements			
C-18.01.07P	test operation	operation is verified by testing circuit for specified voltage, amperage and rotation according to AHJ			
C-18.01.08P	update documentation	documentation is updated to reflect changes carried out			

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

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

Range of Variables

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

C-18.02 Installs HVAC controls

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

	Skills				
	Performance Criteria	Evidence of Attainment			
C-18.02.01P	select tools and equipment	tools and equipment are selected according to task			
C-18.02.02P	calculate circuitry and load requirements	calculations are completed based on voltage and amperage requirements, specifications and CEC requirements			
C-18.02.03P	install control circuit wiring	control circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements			
C-18.02.04P	assemble and install auxiliary control components	auxiliary control components are assembled and installed according to manufacturers' specifications and CEC requirements			
C-18.02.05P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements			
C-18.02.06P	program and test HVAC controls	program is verified by operation of HVAC controls according to specifications, facility and AHJ requirements, and commissioning procedures			
C-18.02.07P	document test results	test results are documented			
C-18.02.08P	determine requirements for isolation and removal of existing HVAC controls when performing an upgrade	isolation and removal requirements of existing HVAC controls when performing an upgrade are determined according to environmental regulations, facility requirements and considering impact removal will have on facility			
C-18.02.09P	update documentation	documentation is updated to reflect changes carried out			

Range of Variables

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

	Knowledge				
	Learning Outcomes	Learning Objectives			
C-18.02.01L	demonstrate knowledge of HVAC and auxiliary control components, their characteristics, applications and operation	identify types of HVAC and <i>auxiliary control components</i> , and describe their characteristics, applications and operation			
		interpret information pertaining to HVAC and <i>auxiliary control components</i> found on drawings and specifications			
		interpret codes and regulations pertaining to HVAC and <i>auxiliary control components</i>			
		identify considerations and requirements for removal of HVAC and <i>auxiliary</i> control components			
		identify considerations and requirements for selecting HVAC and <i>auxiliary control components</i>			
C-18.02.02L	demonstrate knowledge of procedures to install or replace, connect and test HVAC and auxiliary control components	identify tools and equipment used to install or replace, connect and test HVAC and <i>auxiliary control components</i> , and describe their applications and procedures for use			
		describe procedures to isolate and remove HVAC and <i>auxiliary control components</i>			
		describe procedures to install HVAC and auxiliary control components			
		describe procedures to connect HVAC and auxiliary control components			
		describe procedures to test HVAC and auxiliary control components			

auxiliary control components include: time clocks, relays, sensors, thermostats, actuators, electrical interlocks, multiple function controllers, VFD, reduced voltage (soft) starters, discrete and analog devices

C-18.03 Maintains HVAC electrical components

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

	Skills				
	Performance Criteria	Evidence of Attainment			
C-18.03.01P	select tools and equipment	tools and equipment are selected according to task			
C-18.03.02P	verify operation of HVAC electrical components	HVAC electrical components are verified according to manufacturers' specifications and operational requirements by conducting field assessments using diagnostic and test equipment			
C-18.03.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results			
C-18.03.04P	identify and remove defective HVAC electrical components	defective HVAC electrical components are removed without damage to system or other components			
C-18.03.05P	repair malfunctioning HVAC electrical components	repaired HVAC electrical components and equipment are operational			
C-18.03.06P	select replacement HVAC electrical components	OEM or equivalent replacement HVAC electrical components are selected			
C-18.03.07P	install replacement HVAC electrical components and reprogram	OEM or equivalent replacement HVAC electrical components are installed with minimal disruptions and interruptions and are reprogrammed to parameters prior to replacement			
C-18.03.08P	conduct tests of HVAC electrical components	HVAC electrical components are tested after repair, connected and function according to manufacturers' specifications and facility requirements, and system operation is verified			
C-18.03.09P	document tests in maintenance schedule	operational problems are identified in maintenance schedule data			

Range of Variables

HVAC electrical components include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, reduced voltage (soft) starters, discrete and analog sensors field assessments include: sensory inspections, technical inspections, vibration analysis diagnostic and test equipment includes: multimeters, clamp-on ammeters, thermographic imaging devices, non-contact temperature sensor, vibration sensor and analyzer

	Knowledge				
	Learning Outcomes	Learning Objectives			
C-18.03.01L	demonstrate knowledge of complete HVAC system and associated equipment and individual HVAC electrical components	identify terminology associated with HVAC system and associated equipment, and individual HVAC electrical components			
		identify types of HVAC systems and associated equipment , and describe their characteristics, applications and operation			
C-18.03.02L	demonstrate knowledge of interaction between individual <i>HVAC electrical components</i> , and their effect on <i>HVAC system and associated equipment</i>	describe how operation or failure of an individual component impacts other components or complete system			
C-18.03.03L	demonstrate knowledge of procedures to maintain <i>HVAC electrical components</i>	identify tools and equipment used to maintain <i>HVAC electrical components</i> , and describe their applications and procedures for use			
		describe procedures to troubleshoot faults in <i>HVAC electrical components</i>			
		describe procedures to repair and replace HVAC electrical components			
		describe procedures to adjust and reprogram <i>HVAC electrical components</i>			
		describe procedures to verify operation of repaired <i>HVAC electrical components</i>			

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

HVAC electrical components include: motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, reduced voltage (soft) starters, discrete and analog sensors

Task C-19 Installs and maintains electric heating systems and controls

Task Descriptor

Electric heating systems and their associated control devices are sized, installed and connected by industrial electricians. For industrial electricians, electric heating systems include process and environmental heating.

Industrial electricians maintain electric heating systems and their associated controls by performing inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure electric heating systems and their associated control devices are in operating condition. For the purpose of this standard, "install" includes both new installations and upgrading of existing systems by removing and replacing components.

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

C-19.01 Installs electric heating systems and controls

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

	Skills				
	Performance Criteria	Evidence of Attainment			
C-19.01.01P	determine type of <i>electric heating system</i> , and type and ratings of <i>controls</i> required	type of <i>electric heating system</i> is selected according to application, and type and rating of <i>controls</i> are selected according to system requirements			
C-19.01.02P	determine size of <i>electric heating</i> system required	size of <i>electric heating system</i> is selected by referencing <i>heat loss calculations</i> and according to application and AHJ requirements			
C-19.01.03P	select tools and equipment	tools and equipment are selected according to task			
C-19.01.04P	determine branch circuit requirements	branch circuit requirements are determined according to CEC and AHJ requirements			
C-19.01.05P	determine installation location for heating device	heating device locations are determined according to manufacturers' specifications, and facility, CEC and AHJ requirements			
C-19.01.06P	select feeder and/or branch circuit wiring	feeder and/or branch circuit wiring is selected according to drawings, specifications, and facility and CEC requirements			

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C-19.01.07P	install feeder and/or branch circuit wiring	feeder and/or branch circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and CEC and AHJ requirements
C-19.01.08P	install electrical heating device	heating device is installed according to manufacturers' specifications and CEC requirements
C-19.01.09P	install <i>controls</i>	heating controls are installed based on existing systems, and according to manufacturers' specifications and CEC requirements
C-19.01.10P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and CEC and AHJ requirements
C-19.01.11P	test operation	operation is verified by testing circuit voltage, amperage and controls
C-19.01.12P	determine requirements for removal of electric heating systems and controls	removal requirements for <i>electric heating systems</i> and <i>controls</i> are determined according to environmental regulations, facility requirements, and considering impact removal will have on facility
C-19.01.13P	remove existing <i>electric heating</i> 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

electric heating systems include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters controls include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers, flow switches

heat loss calculations include: volume of space being heated, thermal properties of surrounding structure, inside design temperature, outside design temperature

	Knowledge			
	Learning Outcomes	Learning Objectives		
C-19.01.01L	demonstrate knowledge of <i>electric heating systems</i> and <i>controls</i> , their characteristics, applications and operation	identify terminology associated with electric heating systems and controls		
		identify types of <i>electric heating systems</i> , and describe their applications and operation		

		identify types of electric heating <i>controls</i> , and describe their applications and operation
		interpret codes, standards and regulations pertaining to sizing and installing <i>electric heating systems</i> and <i>controls</i>
		identify considerations and requirements for selecting <i>electric heating systems</i> and <i>controls</i> , and their components including existing controls and systems, service capacity, and heating application
		identify considerations and requirements for removal of <i>electric heating systems</i> and <i>controls</i> including safety and loss of heating capacity
C-19.01.02L	demonstrate knowledge of procedures to remove and install <i>electric heating</i> systems and controls	identify tools and equipment used to remove and install <i>electric heating systems</i> and <i>controls</i> , and describe their applications and procedures for use
		describe how <i>heat loss calculations</i> affect the sizing of equipment
		describe procedures to remove <i>electric</i> heating systems and controls
		describe procedures to install <i>electric</i> heating systems and controls

electric heating systems include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters controls include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers, flow switches

heat loss calculations include: volume of space being heated, thermal properties of surrounding structure, inside design temperature, outside design temperature

C-19.02 Maintains electric heating systems and controls

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

	Skills							
	Performance Criteria	Evidence of Attainment						
C-19.02.01P	select tools and equipment	tools and equipment are selected according to task						
C-19.02.02P	verify operation of system	system equipment operation is verified according to manufacturers' specifications and operational requirements by using field assessments and diagnostic and test equipment						
C-19.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results						
C-19.02.04P	identify and remove defective electric heating system components	defective electric heating system components are removed without damage to system or other components						
C-19.02.05P	select replacement components	OEM or equivalent replacement components are selected						
C-19.02.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions and according to manufacturers' specifications						
C-19.02.07P	conduct tests of <i>electric heating</i> systems and controls	electric heating systems and controls are tested after repair, connected and function according to manufacturers' specifications and facility requirements, and system operation verified						
C-19.02.08P	clean and adjust components	electric heating systems and controls components are restored to operating conditions						
C-19.02.09P	update maintenance log	maintenance log is updated to reflect tasks performed						

Range of Variables

field assessments include: sensory inspections, technical inspections
diagnostic and test equipment includes: multimeters, non-contact temperature sensors
electric heating systems include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters
controls include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers

	Knowledge						
	Learning Outcomes	Learning Objectives					
C-19.02.01L	demonstrate knowledge of <i>electric heating systems</i> and <i>controls</i> , their characteristics, applications and operation	identify terminology associated with electric heating systems and controls					
		identify types of <i>electric heating systems</i> , <i>controls</i> and their components, and describe their characteristics, applications and operation					
		describe operation of <i>electric heating</i> system and controls					
C-19.02.02L	demonstrate knowledge of procedures to maintain <i>electric heating systems</i> and <i>controls</i>	identify tools and equipment used to maintain <i>electric heating systems</i> and <i>controls</i> , and describe their applications and procedures for use					
		describe procedures to troubleshoot faults in <i>electric heating systems</i> and <i>controls</i>					
		describe procedures to repair or replace electric heating systems and controls					
		describe procedures to verify operation of repaired <i>electrical heating systems</i> and <i>controls</i>					

electric heating systems include: electric tanks and boiler, convection heaters, radiant heaters, heat tracing cables, heating cable sets, forced air unit heater, induction heaters and other industrial heaters *controls* include: line voltage thermostats, extra-low-voltage thermostats, relays, temperature limit switches, temperature digital controllers

Task C-20 Installs and maintains exit and emergency lighting systems

Task Descriptor

Exit and emergency lighting systems are used to facilitate safe egress from buildings during emergency situations. The systems can be powered by back-up power supplies such as batteries or stand-by generators. The required size and placement are determined by AHJ and building codes. Industrial electricians install and maintain exit and emergency lighting systems.

Industrial electricians maintain exit and emergency lighting systems by performing inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure exit and emergency lighting systems are in operating condition. They also record all inspection and maintenance results according to AHJ.

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

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

C-20.01 Installs exit and emergency lighting systems

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

	Skills						
	Performance Criteria	Evidence of Attainment					
C-20.01.01P	determine type, size, capacity and installation requirements of exit and emergency lighting system required	type, size, capacity and installation requirements of exit and emergency lighting system is determined according to drawings, specifications, and AHJ, CSA and CEC requirements					
C-20.01.02P	calculate connected load	connected load is calculated considering voltage drop according to AHJ, CSA and CEC requirements					
C-20.01.03P	determine branch circuit requirements and standby energy source	branch circuit requirements and standby energy source are determined according to AHJ, CSA and CEC requirements					
C-20.01.04P	determine installation location for exit and emergency lighting system	exit and emergency lighting system locations are determined according to drawings, specifications and AHJ requirements					
C-20.01.05P	select tools and equipment	tools and equipment are selected according to task					
C-20.01.06P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and facility and CEC requirements					

C-20.01.07P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation and without stress, and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.08P	install exit and emergency lighting devices	exit and emergency lighting devices are installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.09P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
C-20.01.10P	test operation	operation is verified by testing circuit for specified voltage, lighting levels and duration of operation
C-20.01.11P	complete documentation	test results are documented according to AHJ, CSA and CEC requirements
C-20.01.12P	determine requirements for removal of exit and emergency lighting system	removal requirements for exit and emergency lighting system are determined according to environmental regulations, facility requirements and considering impact removal will have on facility
C-20.01.13P	remove and dispose of or recycle existing exit and emergency lighting system and update documentation	exit and emergency lighting system is removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-20.01.14P	update documentation	documentation is updated to reflect changes carried out

exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs

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

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

exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs

C-20.02 Maintains exit and emergency lighting systems

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

	Skills								
	Performance Criteria	Evidence of Attainment							
C-20.02.01P	select tools and equipment	tools and equipment are selected according to task							
C-20.02.02P	verify operation of equipment	equipment operation is verified according to manufacturers' specifications and operational requirements by using <i>field</i> assessments and diagnostic and test equipment							
C-20.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results							
C-20.02.04P	identify, remove and dispose of or recycle defective components	defective components are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements							
C-20.02.05P	repair malfunctioning components	repaired components are operational							
C-20.02.06P	select replacement components	OEM or equivalent replacement components are selected							
C-20.02.07P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions according to manufacturers' specifications							
C-20.02.08P	conduct tests of exit and emergency lighting systems	exit and emergency lighting systems are tested after repair, component replacement or as required by maintenance schedule, and are connected and function according to manufacturers' specifications, and AHJ, CSA and CEC requirements, and system operation verified							
C-20.02.09P	document tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data							

Range of Variables

field assessments include: sensory inspections, technical inspections
diagnostic and test equipment includes: multimeter, light intensity meters
exit and emergency lighting systems include: unit equipment, normal and standby (emergency)
powered, remote lighting unit, automatic emergency power transfer control relays, associated wiring
components and circuits, battery packs

	Knowledge							
	Learning Outcomes	Learning Objectives						
C-20.02.01L	demonstrate knowledge of <i>exit and emergency lighting systems</i> , their characteristics, applications and operation	identify terminology associated with <i>exit</i> and emergency lighting systems						
		identify types of exit and emergency lighting systems and describe their characteristics, applications and operation						
		identify exit and emergency lighting system components, and describe their applications and operation						
		describe requirements to record and document test results						
C-20.02.02L	demonstrate knowledge of procedures to maintain <i>exit and emergency lighting systems</i> , and their components	identify tools and equipment used to maintain exit and emergency lighting systems, and their components, and describe their applications and procedures for use						
		describe procedures to maintain <i>exit and emergency lighting systems</i> , and their components						

exit and emergency lighting systems include: unit equipment, normal and standby (emergency) powered, remote lighting units, automatic emergency power transfer control relays, and associated wiring components and circuits, battery packs

Task C-21 Installs and maintains cathodic protection systems

Task Descriptor

Cathodic protection systems refer to impressed DC current cathodic protection systems that introduce an electrical current onto a tank, pipe or structure to limit corrosion and 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 existing systems by removing and replacing components.

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

C-21.01 Installs cathodic protection systems

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

		Skills
	Performance Criteria	Evidence of Attainment
C-21.01.01P	determine installation location for cathodic protection system components	cathodic protection system components installations are determined according to manufacturers' specifications, and facility, AHJ, CSA and CEC requirements
C-21.01.02P	select branch circuit wiring	branch circuit wiring is selected according to manufacturers' specifications and CEC requirements
C-21.01.03P	select tools and equipment	tools and equipment are selected according to task
C-21.01.04P	install branch circuit wiring	branch circuit wiring conductors are installed without damage to insulation, without stress and circuit conductors are identified, selected and installed according to drawings, specifications, and AHJ, CSA and CEC requirements
C-21.01.05P	install cathodic protection system components	cathodic protection system components are installed according to manufacturers' specifications, and AHJ, CSA and CEC requirements
C-21.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers' specifications, and AHJ, CSA and CEC requirements

C-21.01.07P	test operation	operation is verified by testing circuit for specified requirements according to manufacturers' specifications
C-21.01.08P	determine requirements for removal of cathodic protection system components	removal requirements for <i>cathodic protection system components</i> are determined according to environmental regulations, facility requirements and considering impact removal will have on facility
C-21.01.09P	remove existing and dispose of or recycle cathodic protection systems components	cathodic protection system components are removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements
C-21.01.10P	update documentation	documentation is updated to reflect changes carried out

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

	Knowledge							
	Learning Outcomes	Learning Objectives						
C-21.01.01L	demonstrate knowledge of cathodic protection systems and <i>cathodic protection system components</i> , their characteristics, applications and operation	identify terminology associated with cathodic protection systems						
		identify types of cathodic protection systems, and describe their characteristics, applications and operation						
		identify <i>cathodic protection system components</i> , and describe their characteristics, applications and operation						
		interpret information pertaining to cathodic protection systems found on drawings and specifications						
		interpret codes and regulations pertaining to cathodic protection systems						
C-21.01.02L	demonstrate knowledge of procedures to install, connect, and test cathodic protection systems and <i>cathodic</i> protection system components	identify tools and equipment used to install, connect, and test cathodic protection systems and <i>cathodic protection system components</i> , and describe their applications and procedures for use						

describe procedures to install and connect cathodic protection systems and cathodic protection system components				
describe procedures to test cathodic protection systems and cathodic protection system components				

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

C-21.02 Maintains cathodic protection systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
C-21.02.01P	select tools and equipment	tools and equipment are selected according to task			
C-21.02.02P	verify operation of equipment	equipment operation is verified according to manufacturers' specifications and AHJ requirements by using <i>field assessments</i> and <i>diagnostic and test equipment</i>			
C-21.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results			
C-21.02.04P	identify, remove and dispose of or recycle defective <i>cathodic protection system components</i>	defective cathodic protection system components are identified, and removed and disposed of or recycled according to jurisdictional and federal legislation, and waste disposal requirements			
C-21.02.05P	repair malfunctioning cathodic protection system components	repaired <i>cathodic protection system components</i> are operational			
C-21.02.06P	select replacement cathodic protection system components	OEM or equivalent replacement <i>cathodic protection system components</i> are selected			
C-21.02.07P	install bypass jumpers during repair	bypass jumpers are installed to maintain continuity of protection during repair			
C-21.02.08P	install replacement cathodic protection system components	OEM or equivalent replacement <i>cathodic protection system components</i> are installed according to manufacturers' specifications and AHJ requirements			

C-21.02.09P	conduct tests of cathodic protection system components	cathodic protection system components are tested after repair and as required by maintenance schedule, connected and function according to manufacturers' specifications, and facility, AHJ, CSA and CEC requirements, and system operation verified
C-21.02.10P	document test results in maintenance document	operational problems and test results are identified in maintenance schedule data

field assessments include: sensory inspections, technical inspections *diagnostic and test equipment* includes: multimeter, DC ammeter *cathodic protection system components* include: AC supply, transformers, disconnect, rectifiers, associated DC wiring, sacrificial anode, metering, indicators, remote reference points, tap settings in rectifier enclosure, insulation kits, breaker, cabling, jumpers

	Knowledge					
	Learning Outcomes	Learning Objectives				
C-21.02.01L	demonstrate knowledge of <i>cathodic protection systems components</i> , their characteristics, applications and operation	identify terminology associated with cathodic protection systems components				
		identify types of <i>cathodic protection systems components</i> , and describe their characteristics, applications and operation				
C-21.02.02L	demonstrate knowledge of procedures to maintain <i>cathodic protection systems components</i>	identify tools and equipment used to maintain <i>cathodic protection systems components</i> , and describe their applications and procedures for use				
		describe procedures to maintain <i>cathodic</i> protection systems components				

Range of Variables

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

Major Work Activity D

Installs and maintains rotating and other fixed equipment and control systems

Task D-22 Installs and maintains motor starters and control devices

Task Descriptor

All electrical motors need a method to be started, stopped, protected and controlled. These controls can be as simple as a single switch, or as complex as a starter assembly. Industrial electricians install and maintain these starters and controls in the motor circuits. Mechanical starters are being phased out and replaced with solid state starters. This supports energy efficiency and reduces noise pollution. For the purpose of this standard, "install" includes both new installations and upgrading of existing systems by removing and replacing motor starters, control devices and their components. For the purpose of this standard "maintain" includes inspection, preventive/predictive maintenance,

troubleshooting, replacing and repairing activities.

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

	Skills			
	Performance Criteria	Evidence of Attainment		
D-22.01.01P	determine type of <i>motor starter</i> for specific application	motor starter is selected and sized according to specific application, drawings, specifications, motor manufacturers' nameplate data, standards and codes		
D-22.01.02P	select tools and equipment	tools and equipment are selected according to task		
D-22.01.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements		
D-22.01.04P	remove existing motor starter when upgrading	motor starter is removed with minimal impact to surrounding equipment and interruptions to operation		

D-22.01.05P	position, mount and assemble <i>starter</i> assembly	starter assembly is placed, mounted and assembled in locations according to electrical drawings, and job and facility requirements
D-22.01.06P	terminate cables	cables are terminated according to manufacturers' specifications and CEC requirements
D-22.01.07P	terminate conductors	conductors are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-22.01.08P	install overcurrent protection devices	overcurrent protection devices are sized and installed to manufacturers' specifications and CEC requirements
D-22.01.09P	set overloads	overloads are sized for application and adjusted to provide motor running protection according to manufacturers' specifications and CEC requirements
D-22.01.10P	interconnect starter with <i>motor control</i> devices and <i>indicators</i>	interconnections are completed and equipment functions as intended
D-22.01.11P	verify function of <i>motor starter</i>	motor starter is functioning according to application requirements
D-22.01.12P	update documentation	documentation is updated to reflect changes carried out

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

manufacturers' nameplate data includes: size of motor (horsepower), full load current (FLC), service factor, voltage (AC/DC, number of phases), duty, starter size (NEMA, IEC), insulation classification, multivoltage, speed

starter assembly includes: fittings, enclosures, raceways, control transformers, overcurrent protection, overload protection, terminations

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

overcurrent protection devices include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected combination motor controllers

indicators include: indicating lights, audible devices

application requirements include: direction of rotation, RPM, acceleration/deceleration, current draw

	Knowledge					
	Learning Outcomes	Learning Objectives				
D-22.01.01L	demonstrate knowledge of <i>motor starters</i> , their components, accessories, characteristics, applications, and operation	interpret information pertaining to <i>motor</i> starters found on motor nameplate, drawings and specifications				
		identify motor starters and their components and accessories, and describe their characteristics, applications, and operation				
		interpret codes and regulations pertaining to <i>motor starters</i>				
		identify enclosures and wiring methods based on application				
D-22.01.02L	demonstrate knowledge of procedures to install and connect <i>motor starters</i> , their components and accessories	identify tools and equipment used to install and connect <i>motor starters</i> , their components and accessories, and describe their applications and procedures for use				
		describe procedures to install <i>motor</i> starters, their components and accessories				
		describe procedures to connect <i>motor</i> starters, their components and accessories				

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

D-22.02 Maintains motor starters

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

	Skills					
	Performance Criteria	Evidence of Attainment				
D-22.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented				
D-22.02.02P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results				

D-22.02.03P	select tools and equipment	tools and equipment are selected according to task
D-22.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-22.02.05P	repair malfunctioning components	repaired components are operational
D-22.02.06P	select replacement components	OEM or equivalent replacement components are selected
D-22.02.07P	replace defective or damaged components	defective or damaged components are replaced with minimal disruptions and interruptions
D-22.02.08P	clean, lubricate and <i>adjust</i> components	motor starter components are cleaned, lubricated, and <i>adjusted</i> after repair and according to maintenance schedule to restore to OEM <i>component conditions</i>
D-22.02.09P	conduct tests of motor starters after repair	starter assembly is tested after repair and according to maintenance schedule, and is connected and functions according to manufacturers' specifications and facility requirements
D-22.02.10P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-22.02.11P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and comparison with specifications
D-22.02.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-22.02.13P	update documentation	images and drawings reflect operational changes and maintenance history

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

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

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters adjustment procedures include: inspecting terminations, overload settings, timing settings component conditions include: contact pressure, carbon build-up, pitting on contacts, dirt and moisture

	Know	Knowledge					
	Learning Outcomes	Learning Objectives					
D-22.02.01L	demonstrate knowledge of <i>motor starters</i> , their components, accessories, characteristics, applications and operation	interpret information pertaining to <i>motor</i> starters found on drawings and specifications					
		identify <i>motor starters</i> and their components and accessories, and describe their characteristics, applications, and operation					
		interpret codes and regulations pertaining to <i>motor starters</i>					
D-22.02.02L	demonstrate knowledge of procedures to maintain <i>motor starters</i>	identify tools and equipment used to maintain <i>motor starters</i> , and describe their applications and procedures for use					
		describe procedures to maintain <i>motor</i> starters, their components and accessories					

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self protected combination motor controller

D-22.03 Installs motor control devices

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

	Skills						
	Performance Criteria	Evidence of Attainment					
D-22.03.01P	select tools and equipment	tools and equipment are selected according to task					
D-22.03.02P	determine type of <i>motor control device</i> and <i>function</i>	motor control device is selected according to application					
D-22.03.03P	determine motor control circuit and circuit functional features	motor control circuit types are selected according to application and CEC requirements					
D-22.03.04P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements					
D-22.03.05P	remove existing <i>motor control device</i> when replacing	motor control device is removed with minimal impact to surrounding equipment and interruptions to operation					

D-22.03.06P	position, mount and assemble <i>motor</i> control device	motor control device is placed, mounted and assembled in locations according to electrical drawings, and job and facility requirements
D-22.03.07P	terminate cables	cables are terminated according to CEC requirements
D-22.03.08P	terminate conductors	conductors are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-22.03.09P	set up and adjust <i>motor control devices</i>	motor control devices operate according to application
D-22.03.10P	interconnect <i>motor control devices</i> with <i>indicators</i>	motor control devices are interconnected to indicators, and equipment functions as intended
D-22.03.11P	interconnect <i>motor control devices</i> with overload protection	motor control devices are interconnected to overload protection, interconnections are completed and equipment functions as intended
D-22.03.12P	conduct tests of <i>motor control devices</i>	motor control devices are connected and function according to manufacturers' specifications and facility requirements, and results documented

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

functions include: starting and stopping, speed control, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, time function

motor control circuits include: low-voltage release (two-wire control), low-voltage protection (three-wire control)

circuit functional features include: starting and stopping, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, timer function

indicators include: indicating lights, audible devices

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-22.03.01L	demonstrate knowledge of <i>motor control devices</i> , and their characteristics, applications and operation	interpret information pertaining to <i>motor</i> control devices found on drawings and specifications					
		identify <i>motor control devices</i> , and describe their characteristics, applications and operation					
		interpret codes and regulations pertaining to <i>motor control devices</i>					
D-22.03.02L	demonstrate knowledge of <i>motor control circuits</i> , their characteristics and applications	interpret codes and regulations pertaining to <i>motor control circuits</i>					

		identify <i>circuit types</i> , and describe their characteristics and applications
		describe <i>circuit functional features</i> of common hard wired or networked motor control circuits
		identify procedures to determine number of conductors required between controls and controller locations
		identify <i>protection devices</i> for <i>motor control circuits</i> , and describe their characteristics and applications
D-22.03.03L	demonstrate knowledge of procedures to install <i>motor control devices</i>	identify tools and equipment used to install <i>motor control devices</i> , and describe their applications and procedures for use
		describe procedures to install <i>motor</i> control devices

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

motor control circuits include: low-voltage release (two-wire control), low-voltage protection (three-wire control)

circuit functional features include: starting and stopping, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, timer function

protection devices for control circuits include: overcurrent devices

D-22.04 Maintains motor control devices

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

	Skills							
	Performance Criteria	Evidence of Attainment						
D-22.04.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented						
D-22.04.02P	select tools and equipment	tools and equipment are selected according to task						
D-22.04.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results						
D-22.04.04P	identify and remove defective <i>motor</i> control devices and their components	defective motor control devices and their components are removed without damage to system or other components						

D-22.04.05P	clean, lubricate and <i>adjust motor control devices</i> and their components	motor control devices and their components are cleaned, lubricated, and adjusted to restore to OEM conditions
D-22.04.06P	select replacement <i>motor control</i> devices and their components	OEM or replacement <i>motor control devices</i> and their components are selected
D-22.04.07P	install replacement <i>motor control</i> devices and their components	OEM or equivalent replacement <i>motor</i> control devices and their components are installed with minimal disruptions and interruptions
D-22.04.08P	conduct tests of <i>motor control devices</i> and their components	motor control devices and their components are tested after repair and according to maintenance schedule, connected and function according to manufacturers' specifications and facility requirements
D-22.04.09P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-22.04.10P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and comparison with specifications
D-22.04.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-22.04.12P	update documentation	documentation reflects operational changes and maintenance history

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

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

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

field assessments include: sensory inspections, technical inspections (inspecting terminations) **diagnostic and test equipment** includes: multimeters, thermographic imaging devices, ammeters **adjustments** include: calibration (level, position, temperature, timing) of components, securing mounting, positioning

conditions include: carbon or dust build-up, pitting on contacts, worn or dirty contacts

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-22.04.01L	demonstrate knowledge of <i>motor control devices,</i> their components, characteristics, applications and operation	interpret information pertaining to <i>motor</i> control devices found on drawings and specifications					
		identify <i>motor control devices</i> and their components, and describe their characteristics, applications, and operation					
		interpret codes and regulations pertaining to <i>motor control devices</i>					
D-22.04.02L	demonstrate knowledge of procedures to maintain <i>motor control devices</i> and their components	identify tools and equipment used to maintain <i>motor control devices</i> and their components, and describe their applications and procedures for use					
		describe procedures to maintain <i>motor</i> control devices and their components					

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

Task D-23 Installs and maintains drives

Task Descriptor

Electrical motors can be controlled by both AC and DC drives to achieve precision operation (e.g. speed, positioning) of the motors depending on the application. Industrial electricians install and maintain these drives in the motor circuits. They also perform maintenance to ensure motor drives and their controls are in good operating condition. For new installations, DC drives are becoming less common as a result of maintenance issues. AC can be rectified easily at a lower cost with less maintenance requirements.

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

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

Both installation and maintenance include programming and tuning.

D-23.01 Installs AC drives

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

	Skills							
	Performance Criteria	Evidence of Attainment						
D-23.01.01P	determine type, size and function of AC drive	AC drive is determined according to application and <i>motor nameplate data</i>						
D-23.01.02P	select tools and equipment	tools and equipment are selected according to task						
D-23.01.03P	calculate conductor and reactor requirements	conductor and reactor type and size are calculated according to application, taking into account <i>conditions</i> and CEC requirements						
D-23.01.04P	remove existing AC drives when replacing	AC drive is removed with minimal impact to surrounding equipment and interruption to operation						
D-23.01.05P	position, mount and assemble AC drives	AC drive is positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements						
D-23.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements						
D-23.01.07P	install overcurrent protection devices	overcurrent protection devices are installed and sized according to manufacturers' specifications and CEC requirements						

D-23.01.08P	program AC drives	AC drives programming meet functionality and equipment parameters
D-23.01.09P	interconnect AC drives to <i>motor control</i> devices	AC drives are interconnected to motor control devices , required cables, raceways and conductors, and equipment functions as intended
D-23.01.10P	conduct tests of AC drive	AC drive is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-23.01.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.01.12P	update documentation	documentation reflects operational changes, maintenance history and parameters

motor nameplate data includes: size of motor (horsepower), FLC, inverter duty rated, voltage, frequency, speed/rpm

conditions that affect conductor requirements include: shielding requirements, length of cable, type of VFD rated cable, reactor use, equipment bonding

overcurrent protection devices include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected motor controllers

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

	Knowledge				
	Learning Outcomes	Learning Objectives			
D-23.01.01L	demonstrate knowledge of AC drives and AC drive components , their accessories, characteristics, 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			
		identify considerations and requirements for selecting AC drives and AC drive components			

D-23.01.02L	demonstrate knowledge of procedures to install and connect AC drives and AC drive components	identify tools and equipment used to install and connect AC drives and AC drive components, and describe their applications and procedures for use
		describe procedures to install AC drives and AC drive components
		describe procedures to program AC drives and AC drive components

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

D-23.02 Maintains AC drives

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

	Skills			
	Performance Criteria	Evidence of Attainment		
D-23.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented		
D-23.02.02P	select tools and equipment	tools and equipment are selected according to task		
D-23.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results		
D-23.02.04P	identify and remove defective AC drive components	defective <i>AC drive components</i> are removed with minimal impact to surrounding equipment and interruption to operation		
D-23.02.05P	select replacement AC drive components	OEM or equivalent replacement <i>AC drive</i> components are selected		
D-23.02.06P	install replacement AC drive components	OEM or equivalent replacement <i>AC drive components</i> are installed with minimal disruptions and interruptions		
D-23.02.07P	repair malfunctioning AC drive components	repaired AC drive components are operational		
D-23.02.08P	adjust programming	programming is adjusted according to type of repair and changes to operating conditions		

D-23.02.09P	conduct tests of AC drives	AC drive assembly is tested after repair and according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements
D-23.02.10P	clean and adjust components	AC drive components are cleaned and adjusted to restore to optimal conditions
D-23.02.11P	compare and analyze drive parameters	maintenance is performed according to analysis of <i>drive parameters</i>
D-23.02.12P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.02.13P	update documentation	documentation reflects operational changes, maintenance history and parameters

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

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

field assessments include: sensory inspections, technical inspections

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

cleaning and adjustment includes: inspecting terminations, cleaning filters and cooling fans, checking door seals

AC drive components include: rectifiers, EMC filters, inverters, reactors, field components (encoders, tachometers)

drive parameters include: overload, acceleration/deceleration rate, torque, frequency, braking adjust programming includes: using existing program, network

	Knowledge				
	Learning Outcomes	Learning Objectives			
D-23.02.01L	demonstrate knowledge of AC drives and AC drive components , their characteristics, 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 to maintain AC drives and AC drive components	identify tools and equipment used to maintain AC drives and AC drive components, and describe their applications and procedures for use
		describe procedures to maintain AC drives and AC drive components

AC drive components include: rectifiers, EMC filters, inverters, reactors, field components (encoders, tachometers)

D-23.03 Installs DC drives

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

	Skills				
	Performance Criteria	Evidence of Attainment			
D-23.03.01P	determine type, size and function of DC drive for specific application	DC drive is selected and sized according to application and <i>motor nameplate data</i>			
D-23.03.02P	select tools and equipment	tools and equipment are selected according to task			
D-23.03.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements			
D-23.03.04P	remove existing DC drives when replacing	existing DC drive is removed with minimal impact to surrounding equipment and interruption to operation			
D-23.03.05P	position, mount and assemble DC drives	DC drive is positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements			
D-23.03.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturer's specifications, and AHJ, CSA and CEC requirements			
D-23.03.07P	install overcurrent protection devices	overcurrent protection devices are installed and sized according to manufacturers' specifications and CEC requirements			
D-23.03.08P	program DC drives	programming of DC drives meets functionality and established parameters			

D-23.03.09P	interconnect DC drives to <i>motor control</i> devices	DC drives are interconnected to motor control devices with required cables, raceways and conductors, and equipment functions as intended
D-23.03.10P	conduct tests of DC drive	DC drive is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-23.03.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.03.12P	update documentation	documentation reflects operational changes and maintenance history

motor nameplate data includes: size of motor (horsepower), FLC, voltage, speed/rpm *overcurrent protection devices* include: fuses, inverse time circuit breakers, instantaneous trip circuit breakers, self-protected motor controllers

motor control devices include: start/stop stations, emergency stop stations, speed control, sensing devices, encoders, tachometers, limit switches

	Knowledge			
	Learning Outcomes	Learning Objectives		
D-23.03.01L	demonstrate knowledge of DC drives and DC drive components , their characteristics, applications and operation	identify types of DC drives, and describe their characteristics, applications and operation		
		identify <i>DC drive components</i> , and describe their characteristics, applications and operation		
		interpret information pertaining to DC drives found on drawings and specifications		
		interpret codes and regulations pertaining to DC drives		
		explain operating principles of DC drives and their impact on motor performance		
		identify considerations and requirements for selecting DC drives and DC drive components		
D-23.03.02L	demonstrate knowledge of procedures to install and connect DC drives and DC drive components	identify tools and equipment used to install and connect DC drives and DC drive components, and describe their applications and procedures for use		
		describe procedures to install DC drives and DC drive components		

describe procedures to connect DC drives and DC drive components
describe procedures to program DC drives and <i>DC drive components</i>

DC drive components include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, and field components (encoders and tachometers)

D-23.04 Maintains DC drives

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

	Skills						
	Performance Criteria	Evidence of Attainment					
D-23.04.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented					
D-23.04.02P	select tools and equipment	tools and equipment are selected according to task					
D-23.04.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results					
D-23.04.04P	identify and remove defective components	defective components are removed with minimal impact to surrounding equipment and interruption to operation					
D-23.04.05P	select replacement components	OEM or equivalent replacement components are selected					
D-23.04.06P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions					
D-23.04.07P	repair malfunctioning components	repaired components are repaired and tested to ensure they are operational					
D-23.04.08P	conduct tests of DC drives	DC drive assembly is tested after repair and according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements					
D-23.04.09P	clean and adjust components	DC drive components are <i>cleaned and adjusted</i> to restore to optimal conditions					

D-23.04.10P	compare and analyze drive parameters	maintenance is performed according to comparison and analysis of <i>drive</i> parameters
D-23.04.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-23.04.12P	update documentation	documentation reflects operational changes and maintenance history

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

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

field assessments include: sensory inspections, technical inspections

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

cleaning and adjustment includes: inspecting terminations, cleaning filters and cooling fans *drive parameters* include: feedback, acceleration/deceleration rate, torque, braking, max speed/base speed, maximum/minimum field current

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-23.04.01L	demonstrate knowledge of DC drives and DC drive components , their characteristics, 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 to maintain DC drives and <i>DC drive</i> components	identify tools and equipment used to maintain DC drives and <i>DC drive</i> components, and describe their applications and procedures for use					
		describe procedures to maintain DC drives and <i>DC drive components</i>					

DC drive components include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, and field components (encoders and tachometers)

Task D-24 Installs and maintains other fixed equipment and associated controls

Task Descriptor

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

For the purpose of this standard, "other fixed equipment" also includes welders, conveyers, x-ray equipment and other industrial equipment where the equipment at hand can be hardwired or plugged-in. For the purpose of this standard, "install" includes both new installations and upgrading of existing systems by removing and replacing components.

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

D-24.01 Installs other fixed equipment and associated controls

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

	Skills						
	Performance Criteria	Evidence of Attainment					
D-24.01.01P	determine type of other fixed equipment and controls required	other fixed equipment and controls are determined according to manufacturers' specifications, and facility and CEC requirements					
D-24.01.02P	select tools and equipment	tools and equipment are selected according to task					
D-24.01.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements					
D-24.01.04P	install overcurrent protection devices	overcurrent protection devices are installed and sized to manufacturers' specifications and CEC requirements					
D-24.01.05P	remove existing other fixed equipment and controls when replacing	existing other fixed equipment and controls are removed with minimal impact to surrounding equipment and interruption to operation					

D-24.01.06P	position, mount and assemble other fixed equipment and controls	other fixed equipment and controls are positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications and facility requirements
D-24.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ, CSA and CEC requirements
D-24.01.08P	conduct tests of other fixed equipment and controls	other fixed equipment and controls are tested after installation, connected and function according to manufacturers' specifications and facility requirements, and results documented
D-24.01.09P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-24.01.10P	update documentation	documentation reflects changes and maintenance history

other fixed equipment includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

overcurrent protection devices include: fuses, inverse time circuit breakers, instantaneous circuit breakers, self-protected motor controllers

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-24.01.01L	demonstrate knowledge of other fixed equipment and controls, their characteristics, applications and operation	identify types of other fixed equipment and controls, and describe their characteristics, applications and operation					
		identify other fixed equipment components, and describe their characteristics and applications					
		interpret codes and regulations for overcurrent protection, conductor sizing and disconnect locations					
		interpret information found on drawings and specifications					
		explain operating principles of other fixed equipment and controls					
		interpret information contained on other fixed equipment nameplates					
		identify considerations and requirements for selecting other fixed equipment and controls, and their components					

D-24.01.02L	demonstrate knowledge of procedures to install and connect other fixed equipment and controls	identify tools and equipment used to install and connect other fixed equipment and controls, and describe their applications and procedures for use
		describe procedures to install other fixed equipment and controls
		describe procedures to connect other fixed equipment and controls

other fixed equipment includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

D-24.02 Maintains other fixed equipment and associated controls

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

	Skills						
	Performance Criteria	Evidence of Attainment					
D-24.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented					
D-24.02.02P	select tools and equipment	tools and equipment are selected according to task					
D-24.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results					
D-24.02.04P	identify and remove defective components	defective <i>components</i> are removed without damage to system or other <i>components</i>					
D-24.02.05P	select replacement <i>components</i>	OEM or equivalent replacement components are selected					
D-24.02.06P	install replacement <i>components</i>	OEM or equivalent replacement components are installed with minimal disruptions and interruptions					
D-24.02.07P	conduct tests of other fixed equipment and controls	other fixed equipment and controls are tested after repair or according to maintenance schedule, and assembly is connected and functions according to specifications					
D-24.02.08P	clean and adjust <i>components</i>	components are cleaned and adjusted to restore to optimal conditions					

D-24.02.09P	compare and analyze maintenance <i>test</i> results	maintenance is performed when required according to analysis of <i>test</i> results and comparison with specifications
D-24.02.10P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-24.02.11P	update documentation	documentation reflects changes and maintenance history

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

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

field assessments include: sensory inspections, technical inspections

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

components include: overcurrent protection, conductors, disconnects, cord sets

other fixed equipment includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

tests include: insulation, current, baseline

	Knov	vledge		
	Learning Outcomes	Learning Objectives		
D-24.02.01L	demonstrate knowledge of other fixed equipment and controls, their components, characteristics, applications and operation	identify types of other fixed equipment and controls, and describe their characteristics, applications and operation		
		identify other fixed equipment components, and describe their characteristics and applications		
		interpret codes and regulations		
		interpret information found on drawings and specifications		
		explain industrial and operating principles of other fixed equipment and controls		
D-24.02.02L	demonstrate knowledge of procedures to maintain other fixed equipment and controls, and their components	identify tools and equipment used to maintain other fixed equipment and controls, and describe their applications and procedures for use		
		describe procedures to maintain other fixed equipment and controls, and their components		

other fixed equipment includes: welding equipment, electro-magnets, electrostatic precipitators, industrial equipment, x-ray equipment, conveyers, charging equipment

Task D-25 Installs and maintains motors

Task Descriptor

Motors are used to convert electrical energy to rotational kinetic (mechanical) energy. Industrial electricians install and maintain single-phase, three-phase and DC motors.

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

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

D-25.01 Installs single-phase motors

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

	Skills					
	Performance Criteria	Evidence of Attainment				
D-25.01.01P	determine type of single-phase motor required	type of single-phase motor is selected according to operating considerations				
D-25.01.02P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements				
D-25.01.03P	select tools and equipment	tools and equipment are selected according to task				
D-25.01.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <i>motor nameplate data</i> and CEC requirements				
D-25.01.05P	position, mount and assemble single - phase motor	single-phase motor is positioned, mounted and assembled according to application				
D-25.01.06P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications				
D-25.01.07P	connect motor leads	motor leads are connected according to application, supply voltage and rotation				

D-25.01.08P	conduct tests of single-phase motor	single-phase motor is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented		
D-25.01.09P	remove existing single-phase motor when replacing	existing single-phase motor is removed with minimal impact to environment		
D-25.01.10P	update documentation	documentation reflects operational changes and maintenance history		

single-phase motors include: universal, shaded pole, resistance-start-induction-run (split phase), capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

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

motor nameplate data includes: size of motor (horsepower), FLC, service factor, voltage, duty, speed/rpm, frequency, insulation class, ambient temperature, enclosure type *tests* include: vibration, insulation, current, rotation, baseline motor diagnostic test

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

describe procedures to install <i>single- phase motors</i> and <i>single-phase motor components</i>
describe procedures to connect single- phase motors and single-phase motor components

single-phase motors include: universal, shaded pole, resistance-start-induction-run, capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

single-phase motor components include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

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

D-25.02 Maintains single-phase motors

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

	SI	kills
	Performance Criteria	Evidence of Attainment
D-25.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented
D-25.02.02P	select tools and equipment	tools and equipment are selected according to task
D-25.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results
D-25.02.04P	identify and remove defective single- phase motor components	defective single-phase motor components are removed without damage to system or other components
D-25.02.05P	select replacement single-phase motor components	OEM or equivalent replacement single- phase motor components are selected
D-25.02.06P	install replacement single-phase motor components	OEM or equivalent replacement single- phase motor components are installed with minimal disruptions and interruptions
D-25.02.07P	conduct <i>tests</i> of single-phase motors	single-phase motor assembly is tested after repair and according to maintenance schedule, connected and functions according to specifications
D-25.02.08P	clean, lubricate and adjust single- phase motor components	single-phase motor components are cleaned, lubricated, and adjusted to restore to optimal conditions

D-25.02.09P	document <i>test</i> results in maintenance schedule	operational problems and <i>test</i> results are documented in maintenance schedule data with detailed notations
D-25.02.10P	compare and analyze maintenance <i>test</i> results	maintenance is performed according to analysis of <i>test</i> results and comparison with specifications
D-25.02.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.02.12P	update documentation	documentation reflects operational changes and maintenance history

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

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

field assessments include: sensory inspections, technical inspections

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

single-phase motor components include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

clean, lubricate and adjust includes: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches

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

	Knowledge						
	Learning Outcomes	Learning Objectives					
D-25.02.01L	demonstrate knowledge of single-phase motors and single-phase motor components, their characteristics, applications and operation	identify types of single-phase motors and describe their characteristics, applications and operation					
		identify terminology pertaining to single- phase motors					
		identify single-phase motor components, and describe their applications					
		interpret codes and regulations pertaining to single-phase motors					
		interpret information found on drawings and specifications					
		explain industrial and operating principles of <i>single-phase motors</i>					
		interpret information contained on single- phase motor nameplates					

D-25.02.02L	demonstrate knowledge of procedures to maintain <i>single-phase motors</i> and <i>single-phase motor components</i>	identify tools and equipment used to maintain <i>single-phase motors</i> and <i>single-phase motor components</i> , and describe their applications and procedures for use
		describe procedures to maintain single- phase motors and single-phase motor components

single-phase motors include: universal, shaded pole, resistance-start-induction-run, capacitor-start-induction-run, capacitor-start-capacitor-run, hermetically sealed

single-phase motor components include: frame, centrifugal switch, rotor, stator, end bells, fans, bearings, bushings, capacitors

D-25.03 Installs three-phase motors

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

	Skills						
	Performance Criteria	Evidence of Attainment					
D-25.03.01P	determine type of <i>three-phase motor</i> required	type of <i>three-phase motor</i> is selected according to <i>operating considerations</i>					
D-25.03.02P	select tools and equipment	tools and equipment are selected according to task					
D-25.03.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements					
D-25.03.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <i>motor nameplate data</i> and CEC requirements					
D-25.03.05P	position and mount three-phase motor	three-phase motor is placed, mounted and assembled according to application					
D-25.03.06P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications					
D-25.03.07P	connect motor leads	motor leads are connected according to application, supply voltage and rotation					
D-25.03.08P	conduct <i>tests</i> of <i>three-phase motor</i>	three-phase motor is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented					

D-25.03.09P	remove existing <i>three-phase motor</i> when replacing	motor when existing three-phase motor is removed with minimal impact to environment			
D-25.03.10P	update documentation	documentation reflects changes and maintenance history			

three-phase motors include: squirrel cage induction, synchronous, wound rotor induction
 operating considerations include: supply voltage, motor function, rotation, location
 motor nameplate data includes: size of motor (horsepower), FLC, service factor, voltage, speed/rpm, frequency, insulation class, ambient temperature, enclosure type, duty cycle
 tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

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

Range of Variables

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

D-25.04 Maintains three-phase motors

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

	Skills							
	Performance Criteria	Evidence of Attainment						
D-25.04.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented						
D-25.04.02P	select tools and equipment	tools and equipment are selected according to task						
D-25.04.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results						
D-25.04.04P	identify and remove defective <i>three- phase motor components</i>	defective <i>three-phase motor components</i> are removed without damage to system or other components						
D-25.04.05P	select replacement three-phase motor components	OEM or equivalent replacement <i>three-phase motor components</i> are selected						
D-25.04.06P	install replacement three-phase motor components	OEM or equivalent replacement three- phase motor components are installed with minimal disruptions and interruptions						
D-25.04.07P	conduct tests of three-phase motors	three-phase motor assembly is tested after repair and according to maintenance schedule, connected and functions according to specifications						
D-25.04.08P	clean, lubricate and adjust three-phase motor components	three-phase motor components are cleaned, lubricated and adjusted to restore to optimal conditions						
D-25.04.09P	document <i>test</i> results in maintenance schedule	operational problems and <i>test</i> results are identified and documented in maintenance schedule data with detailed notations						
D-25.04.10P	compare and analyze maintenance <i>test</i> results	maintenance is performed according to according to analysis of <i>test</i> results and comparison with specifications						
D-25.04.11P	label conductors and corresponding terminals or leads	conductors and corresponding terminals are labelled according to drawings and specifications						
D-25.04.12P	update documentation	documentation reflects changes and maintenance history						

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

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

field assessments include: sensory inspections, technical inspections

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

tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test **clean, lubricate and adjust** includes: cleaning cooling fans, lubricating bearings, cleaning switches, checking slip rings and brushes

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

three-phase motor components include: frame, rotor, stator, end bells, fans, brushes, bearings, slip rings, lifting eyes

	Knowledge				
	Learning Outcomes	Learning Objectives			
D-25.04.01L	demonstrate knowledge of <i>three-phase motors</i> and <i>three-phase motor components</i> , their characteristics, applications and operation	identify types of <i>three-phase motors</i> , and describe their characteristics, applications and operation			
		identify terminology pertaining to <i>three-phase motors</i>			
		identify <i>three-phase motor components</i> , and describe their characteristics and applications			
		interpret codes and regulations pertaining to <i>three-phase motors</i>			
		interpret information found on drawings and specifications			
		explain operating principles of <i>three- phase motors</i>			
		interpret information contained on three- phase motor nameplates			
D-25.04.02L	demonstrate knowledge of procedures to maintain <i>three-phase motors</i> and <i>three-phase motor components</i>	identify tools and equipment used to maintain <i>three-phase motors</i> and <i>three-phase motor components</i> , and describe their applications and procedures for use			
		describe procedures to maintain three- phase motors and three-phase motor components			

three-phase motors include: squirrel cage induction, wound rotor induction, synchronous *three-phase motor components* include: frame, rotor, stator, end bells, fans, brushes, bearings, slip rings, lifting eyes

D-25.05 Installs DC motors

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

		Skills
	Performance Criteria	Evidence of Attainment
D-25.05.01P	determine type of <i>DC motor</i> required	DC motor to be installed is determined according to operating conditions
D-25.05.02P	select tools and equipment	tools and equipment are selected according to task
D-25.05.03P	calculate conductor requirements	conductor type and size are calculated according to CEC requirements
D-25.05.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to <i>motor nameplate data</i> and CEC requirements
D-25.05.05P	remove existing DC motors when replacing	existing DC motors are removed with minimal impact to environment
D-25.05.06P	position and mount <i>DC motor</i>	DC motor is positioned and mounted according to application
D-25.05.07P	connect motor leads	motor leads are connected according to application, supply voltage, rotation and configuration
D-25.05.08P	conduct <i>tests</i> of <i>DC motor</i>	DC motor is tested after installation, connected and functions according to manufacturers' specifications and facility requirements, and results documented
D-25.05.09P	label conductors and corresponding conductors and corresponding terminals are labelled according to drawings specifications	
D-25.05.10P	update documentation	documentation reflect changes and maintenance history

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination **operating conditions** include: voltage availability, motor function, rotation, location **motor nameplate data** includes: base speed/rpm, size of motor (horsepower), FLC, service factor, voltage, insulation class, ambient temperature, enclosure type, duty cycle **tests** include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test

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

Range of Variables

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination **DC motor components** include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

D-25.06 Maintains DC motors

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

	SI	kills
	Performance Criteria	Evidence of Attainment
D-25.06.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented
D-25.06.02P	select tools and equipment	tools and equipment are selected according to task
D-25.06.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results
D-25.06.04P	identify and remove defective <i>DC motor</i> components	defective DC motor components are removed without damage to system or other components
D-25.06.05P	select replacement <i>DC motor</i> components	OEM or equivalent replacement DC motor components are selected
D-25.06.06P	install replacement <i>DC motor</i> components	OEM or equivalent replacement DC motor components are installed with minimal disruptions and interruptions
D-25.06.07P	conduct <i>tests</i> of <i>DC motors</i>	DC motor assembly is tested after repair or according to maintenance schedule, connected and functions according to manufacturers' specifications and facility requirements
D-25.06.08P	clean, lubricate and adjust DC motor components	DC motor components are cleaned, lubricated, and adjusted to restore to optimal conditions
D-25.06.09P	document test results in maintenance schedule	operational problems and test results are identified and documented in maintenance schedule data with detailed notations
D-25.06.10P	compare and analyze maintenance <i>test</i> results	maintenance is performed according to analysis of <i>test</i> results and comparison with specifications
D-25.06.11P	label conductors and corresponding terminals	conductors and corresponding terminals are labelled according to drawings and specifications
D-25.06.12P	update documentation	documentation reflects changes and maintenance history

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

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

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination *field assessments* include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, thermographic imaging devices, ammeters, insulation resistance testers, isolated oscilloscope, DC hi-pot testers, growlers

tests include: vibration, insulation, current, rotation, alignment, baseline motor diagnostic test **clean, lubricate and adjust** includes: cleaning cooling fans, lubricating bearings and bushings, cleaning switches, cleaning and adjusting brushes, cleaning commutator segments

DC motor components include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

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

Range of Variables

DC motors include: self-excited, separately excited, series, shunt, compound, dual field/combination **DC motor components** include: frame, armature and field windings, commutator, end bells, fans, brushes, brush holders, bearings, bushings

Major Work Activity E

Installs and maintains signalling and communication systems

Task E-26 Installs and maintains signalling systems

Task Descriptor

Industrial electricians install, upgrade, and maintain signalling systems such as fire alarm systems, and security and surveillance systems which allow for the protection and management of people and property. These types of systems may be low-voltage circuits, extra-low-voltage circuits, and Class 1 or Class 2 circuits.

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

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

E-26.01 Installs fire alarm systems

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

	Skills			
	Performance Criteria	Evidence of Attainment		
E-26.01.01P	determine type of <i>fire alarm system</i> required	type of <i>fire alarm system</i> is determined according to electrical drawings, specifications, <i>codes, standards and regulations</i>		
E-26.01.02P	select tools and equipment	tools and equipment are selected according to task		
E-26.01.03P	remove and dispose of or recycle existing fire alarm system components when upgrading	fire alarm system components are disposed of or recycled according to codes and waste disposal requirements		
E-26.01.04P	determine <i>fire alarm system</i> layout	fire alarm system layout is determined according to walkthrough of building to identify and mark interference locations on drawings according to manufacturers' specifications, codes, standards and regulations		

E-26.01.05P	select fire alarm system components	fire alarm system components are selected according to electrical drawings, manufacturers' specifications, codes, standards and regulations
E-26.01.06P	position, mount and assemble <i>fire alarm</i> system components	fire alarm system components are positioned, mounted and assembled in locations according to electrical drawings, codes, standards and regulations
E-26.01.07P	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, codes, standards and regulations
E-26.01.08P	test fire alarm system components	fire alarm system components are tested to ensure functionality
E-26.01.09P	test cables	cables are tested for continuity, shorts between conductors, and shorts between conductors and ground
E-26.01.10P	conduct an initial test of <i>fire alarm</i> system	sensory and spot tests and initial <i>fire</i> alarm system tests are performed according to manufacturers' specifications, codes, standards and regulations
E-26.01.11P	participate in start-up, commissioning and verification	start-up, commissioning and verification is conducted on <i>fire alarm system</i> , <i>fire alarm system components</i> and associated systems according to design and manufacturers' specifications, codes, standards and regulations
E-26.01.12P	update documentation for fire alarm systems	documentation is updated according to codes, standards and regulations, and reflects commissioning activities

fire alarm systems include: addressable (data communication link, Class A [DCLA]- data communication link, Class B [DCLB]- data communication link, Class C [DCLC]) and non-addressable (Class A – Class B) systems (single stage, two stage, single zone, multi-zone)

fire alarm system components include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

associated systems include: fire suppression systems, emergency power supplies fan shutdown/startup, public address (PA) systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

codes, standards and regulations include: CAN/Underwriters Laboratory of Canada (ULC)-S524, CAN/ULC-S536, CAN/ULC-S537, National Building Code (NBC) and local building codes, National Fire Code of Canada (NFC) and local fire codes, CEC, regulations specific to AHJ

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

	Knov	Knowledge				
	Learning Outcomes	Learning Objectives				
E-26.01.01L	demonstrate knowledge of <i>fire alarm</i> systems and <i>fire alarm</i> system components, their characteristics, applications and operation	interpret codes, standards and regulations pertaining to fire alarm systems				
		interpret information found on drawings and manufacturers' specifications				
		identify types of <i>fire alarm systems</i> , and describe their characteristics and applications				
		describe types of associated systems that are interconnected with fire alarm systems				
		identify <i>fire alarm system components</i> , and describe their characteristics and applications				
		identify considerations and requirements for selecting <i>fire alarm systems</i> and <i>fire alarm system components</i>				
E-26.01.02L	demonstrate knowledge of procedures to install, upgrade and connect <i>fire alarm</i> systems and <i>fire alarm system</i> components, and their connections to associated/ancillary systems	identify tools and equipment used to install, upgrade and connect <i>fire alarm</i> systems and <i>fire alarm system</i> components, and their connections to associated/ancillary systems, and describe their applications and procedures for use				
		describe procedures to install, upgrade and connect <i>fire alarm systems</i> and <i>fire alarm system components</i>				

describe procedures to interconnect associated/ancillary systems with fire alarm systems
describe procedures for testing <i>fire alarm</i> systems and <i>fire alarm system</i> components
describe procedures for start-up, commissioning and verification of <i>fire</i> alarm systems

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

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

associated/ancillary systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

fire alarm system components include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

E-26.02 Maintains fire alarm systems

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

	Skills						
	Performance Criteria	Evidence of Attainment					
E-26.02.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented					
E-26.02.02P	select tools and equipment	tools and equipment are selected according to task					
E-26.02.03P	identify existing <i>fire alarm system</i> and <i>fire alarm system components</i>	existing <i>fire alarm system</i> and <i>fire alarm system components</i> are identified according to <i>documentation</i>					
E-26.02.04P	test fire alarm system	tests are performed according to codes , standards and regulations , manufacturers' specifications and maintenance schedule; sensory inspections and technical inspections are performed using diagnostic and test equipment					

E-26.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation
E-26.02.06P	participate in periodic inspections	fire alarm system, fire alarm system components, and associated/ancillary systems function according to manufacturers' specifications and are inspected according to maintenance schedule
E-26.02.07P	select replacement fire alarm system components	OEM or equivalent replacement <i>fire</i> alarm system components are selected according to manufacturers' specifications, facility requirements, codes, standards and regulations
E-26.02.08P	replace fire alarm system components	OEM or equivalent replacement <i>fire</i> alarm system components are tested and verified according to codes, standards and regulations
E-26.02.09P	participate in start-up and verification	start-up and verification is conducted on fire alarm system, fire alarm system components and associated systems according to design and manufacturers' specifications, and codes, standards and regulations
E-26.02.10P	update documentation	documentation is clear, detailed and includes systems and components tested, test results and changes that were completed according to codes, standards and regulations

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

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

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

fire alarm system components include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

diagnostic and test equipment includes: multimeters, voltage testers, sound pressure level (SPL) meters, heat lamp, smoke canisters

associated/ancillary systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

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

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

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

E-26.02.02L	demonstrate knowledge of procedures to maintain <i>fire alarm systems</i> and <i>fire alarm system components</i>	identify tools and equipment used to maintain <i>fire alarm systems</i> and <i>fire alarm system components</i> , and describe their applications and procedures for use		
		describe procedures to service and maintain fire alarm systems and fire alarm systems		
		describe procedures for testing fire alarm systems and fire alarm system components		

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

codes, standards and regulations include: CAN/ULC-S524, CAN/ULC-S536, CAN/ULC-S537, NBC and local building codes, NFC and local fire codes, CEC, CSA standard M421

fire alarm system components include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches) and signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

associated/ancillary systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, remote monitoring, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans), fire pump

E-26.03 Installs security and surveillance systems

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

	Skills							
	Performance Criteria	Evidence of Attainment						
E-26.03.01P	identify type of 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	select tools and equipment	tools and equipment are selected according to task						
E-26.03.03P	remove and dispose of existing security and surveillance system when upgrading	all security and surveillance system components are disposed of according to environmental standards and regulations						
E-26.03.04P	determine security and surveillance system layout	security and surveillance system layout is determined according to architectural and facility requirements						

E-26.03.05P	select security and surveillance system components	security and surveillance system components are selected according to electrical drawings, specifications, job and facility requirements
E-26.03.06P	position, mount and assemble security and surveillance system components	security and surveillance system components are positioned, mounted and assembled in locations according to electrical drawings, specifications, and job and facility requirements
E-26.03.07P	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-26.03.08P	program and configure security and surveillance system	security and surveillance system is programmed and configured according to manufacturers' specifications, and job and facility requirements
E-26.03.09P	test cables	cables are tested for continuity and polarity of voice data and video data wiring ensuring cables have no opens and all security and surveillance system components are bonded to ground according to CEC requirements
E-26.03.10P	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 requirements
E-26.03.11P	participate in start-up and commissioning inspections	devices are activated to trigger events, and associated systems' responses according to manufacturers' specifications and facility requirements
E-26.03.12P	update documentation to reflect testing, inspections and maintenance performed	documentation is clear, detailed and includes systems and components tested, test results and changes that were completed

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, digital video recorders (DVR), motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, radio frequency identification (RFID) tags, key pads, power supplies, servers, graphical user interfaces (GUI)

events include: system surveillance logs, notifications, alarms

associated systems include: central alarm monitoring, automatic doors, local area network (LAN), building automation systems, lighting

documentation includes: maintenance logs, as-builts

	Know	rledge
	Learning Outcomes	Learning Objectives
E-26.03.01L	demonstrate knowledge of security and surveillance systems and security and surveillance system components, their characteristics, 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, applications and operation
		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
		identify considerations and requirements for selecting security and surveillance systems and security and surveillance system components
E-26.03.02L	demonstrate knowledge of procedures to install, upgrade and connect security and surveillance systems and security and surveillance system components	identify tools and equipment used to install, upgrade and connect security and surveillance systems and security and surveillance system components, and describe their applications and procedures for use
		describe procedures to install, upgrade and connect security and surveillance systems and security and surveillance system components
		describe procedures for testing security and surveillance systems and security and surveillance system components
		describe procedures for start-up, commissioning and verification of security and surveillance systems

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs **associated systems** include: central alarm monitoring, automatic doors, LAN, building automation systems, lighting

E-26.04 Maintains security and surveillance systems

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

	Skills							
	Performance Criteria	Evidence of Attainment						
E-26.04.01P	obtain detailed description of malfunction	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented						
E-26.04.02P	select tools and equipment	tools and equipment are selected according to task						
E-26.04.03P	identify existing security and surveillance system and security and surveillance system components	as-built drawings and maintenance log are referenced to identify existing security and surveillance system and a walkthrough is conducted						
E-26.04.04P	conduct security and surveillance system tests	security and surveillance system tests are performed according to sensory inspections, and technical inspections using diagnostic equipment and software						
E-26.04.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation						
E-26.04.06P	select replacement security and surveillance system components	OEM or equivalent replacement security and surveillance system components are selected						
E-26.04.07P	replace defective security and surveillance system components	defective security and surveillance system components are replaced						
E-26.04.08P	program and configure security and surveillance system	security and surveillance system is programmed and configured according to job and facility requirements						
E-26.04.09P	clean and adjust security and surveillance system components	security and surveillance system components are cleaned, adjusted and function according to location conditions and facility requirements						
E-26.04.10P	update documentation to reflect testing, inspections and maintenance performed	documentation is clear, detailed and includes security and surveillance systems and security and surveillance system components tested, test results and changes completed						
E-26.04.11P	notify and explain system changes to system monitor	system changes are explained to system monitor						

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

security and surveillance systems include: perimeter, space, spot

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

documentation includes: maintenance logs, as-builts, latest inspection report

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognition, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs **diagnostic equipment and software** includes: multimeters, voltage testers, network cable analyzers, internal diagnostic software

	Knowledge						
	Learning Outcomes	Learning Objectives					
E-26.04.01L	demonstrate knowledge of security and surveillance systems and security and surveillance system components, their characteristics, applications and operation	identify types of security and surveillance systems , and describe their characteristics, applications and operation					
		interpret information found on drawings and specifications					
		interpret codes and regulations pertaining to security and surveillance systems					
		identify security and surveillance system components , and describe their characteristics and applications					
		identify considerations and requirements for selecting security and surveillance systems and security and surveillance system components					
		describe types of associated systems that interconnect with security and surveillance systems					
		describe possible effects of security and surveillance system maintenance on associated systems					
E-26.04.02L	demonstrate knowledge of procedures to maintain security and surveillance systems and security and surveillance system components	identify tools and equipment used to maintain security and surveillance systems and security and surveillance system components, and describe their applications and procedures for use					
		describe procedures to maintain security and surveillance systems and security and surveillance system components					

describe procedures for testing security and surveillance systems, security and surveillance system components and cables
describe procedures for commissioning and verification of security and surveillance systems

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, magnetic locks, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, RFID tags, key pads, power supplies, servers, GUIs **associated systems** include: central alarm monitoring, automatic doors, LAN, building automation systems, lighting

cables include: fibre optic, structured/category (category 5e, 6, 6A, 8), coaxial, twisted pairs, extra-low-voltage (LVT, ELC), shielded pairs, triads, quads

Task E-27 Installs and maintains communication systems

Task Descriptor

Communication systems allow information to be transmitted by voice, sound, lighting and data from one point to another, using wireless and structured cabling, which includes fiber optic, copper and coaxial cables. These types of systems may include Class 1 and Class 2 circuits, low-voltage power circuit, extra-low-voltage power circuit or low-energy power circuit. They include voice/data/video (VDV), voice over Internet protocol (VoIP), closed circuit television (CCTV), public address (PA), intercom, and various other industrial data communication systems.

Industrial data communication systems such as DeviceNet, Ethernet, Modbus are prevalent in the control environment for industrial electricians. Modbus is typically found on existing systems while newer systems use DeviceNet and Ethernet. Wireless technology is also becoming prevalent.

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

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

E-27.01 Installs communication systems

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

	Skills							
	Performance Criteria	Evidence of Attainment						
E-27.01.01P	determine type of communication system required	type of communication system is determined according to electrical drawings, specifications, and job and facility requirements						
E-27.01.02P	select tools and equipment	tools and equipment are selected according to task						
E-27.01.03P	determine <i>communication system</i> layout	communication system layout is determined according to drawings, and job and facility requirements						
E-27.01.04P	select communication system components	communication system components are selected according to electrical drawings, specifications, and job and facility requirements						
E-27.01.05P	position, mount and assemble communication system components	communication system components are positioned, mounted and assembled in locations according to electrical drawings, manufacturers' specifications, and job and facility requirements						

E-27.01.06P	terminate and interconnect communication system components and associated systems	communication system components and associated system are terminated and interconnected according to electrical drawings, manufacturers' specifications, and job and AHJ requirements
E-27.01.07P	test cables for continuity, polarity, opens and grounds	voice data and video data wiring are tested ensuring cables have no opens and all <i>communication system</i> components are bonded to ground
E-27.01.08P	program and configure <i>communication</i> system	communication system is programmed and configured according to manufacturers' specifications, and job and facility requirements
E-27.01.09P	determine and configure device address	devices are addressed to enable communication and not interfere with existing systems
E-27.01.10P	remove and dispose of or recycle existing communication system components and update documentation	communication system components are disposed of or recycled according to local codes and waste disposal requirements, and documentation updated
E-27.01.11P	conduct initial communication system tests	sensory and spot tests are performed, and <i>communication system</i> tests are performed according to electrical drawings and specifications
E-27.01.12P	participate in startup/restart and commissioning inspections	devices are activated to trigger events, and associated systems' responses
E-27.01.13P	update documentation	documentation is updated to reflect commissioning activities

communication systems include: VDV and CCTV systems (unshielded twisted pair [UTP], screened twisted pair [ScTP]), data cables, fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [DAS] [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

communication system components include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

associated systems include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA **events** include: digital system logs, notifications, alarms

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

	Knowledge						
	Learning Outcomes	Learning Objectives					
E-27.01.01L	demonstrate knowledge of communication systems and communication system components, their characteristics, applications, operation and interconnection	identify types of <i>communication systems</i> , and describe their characteristics, applications and operation					
		interpret information found on drawings and specifications					
		interpret codes, standards and regulations pertaining to <i>communication systems</i>					
		describe types of associated systems that interconnect with communication systems					
		identify communication system components, and describe their characteristics and applications					
		identify considerations and requirements for selecting <i>communication systems</i> and <i>communication system components</i>					
		describe possible effects of communication system maintenance on associated systems					
E-27.01.02L	demonstrate knowledge of procedures to install, configure, upgrade and connect communication systems and communication system components	identify tools and equipment used to install, configure, upgrade and connect communication systems and communication system components, and describe their applications and procedures for use					
		describe procedures to install, configure, upgrade and connect communication systems and communication system components					
		describe procedures for testing communication systems and communication system components					
		describe procedures for commissioning and verification of <i>communication</i> systems					

communication systems include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multimode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

associated systems include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA **communication system components** include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

diagnostic and test equipment includes: TDRs, optical time-domain reflectometer (OTDRs), cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters

E-27.02 Maintains communication systems

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

	Skills							
	Performance Criteria	Evidence of Attainment						
E-27.02.01P	select tools and equipment	tools and equipment are selected according to task						
E-27.02.02P	identify existing communication systems and communication system components	existing communication systems and communication system components are identified according to documentation						
E-27.02.03P	obtain detailed description of malfunction or maintenance requirements	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented						
E-27.02.04P	test communication systems	tests are performed according to sensory inspections and technical inspections using diagnostic and test equipment						
E-27.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation						
E-27.02.06P	replace communication system components	replacement <i>communication system components</i> are tested and verified						

E-27.02.07P	update documentation to reflect testing, inspections or maintenance performed	documentation is clear and detailed and includes communication systems and communication system components tested, test results and changes completed
E-27.02.08P	notify and explain system changes to facility representatives or personnel	facility representatives or personnel are informed of system changes according to notification process and chain of command

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

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

communication systems include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multimode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling), Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

communication system components include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

diagnostic and test equipment includes: TDRs, OTDRs, cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters, network analyzer

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

	Knowledge							
	Learning Outcomes	Learning Objectives						
E-27.02.01L	demonstrate knowledge of communication systems and communication system components, their characteristics, applications, operation and interconnection	identify types of <i>communication systems</i> , and describe their characteristics, applications and operation						
		interpret information found on drawings and specifications						
		interpret codes, standards and regulations pertaining to <i>communication systems</i>						
		identify communication system components, and describe their characteristics and applications						

		describe types of associated systems that interconnect with communication systems
		describe possible effects of communication systems and maintenance on associated systems
E-27.02.02L	demonstrate knowledge of procedures to maintain <i>communication systems</i> and <i>communication system components</i>	identify tools and equipment used to maintain <i>communication systems</i> and <i>communication system components</i> , and describe their applications and procedures for use
		describe procedures to maintain communication systems and communication system components
		describe procedures for testing communication systems, communication system components and cables
		describe procedures for verification of communication systems

communication systems include: VDV and CCTV systems (UTP, ScTP, data cables, fiber optic, multimode and single-mode, coaxial and DAS [wireless]), PA systems (perimeter and space), intercom systems (one-to-one, one-to-many), one-way, two-way, audible and visual, direct wire, IP based/structured cabling, Internet, industrial data communication systems (Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet, ControlNet)

associated systems include: building control systems, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, energy management system, SCADA

communication system components include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection for communication cabling systems, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware, microphones, speakers, bells, tone generators, panels, handsets, door release strikes, GUIs, cameras, monitors, RFID tags, annunciator, key pads

diagnostic and test equipment includes: TDRs, OTDRs, cable analyzers, light source power meters, wire map testers, multimeters, ohmmeters, network analyzer

Task E-28 Installs and maintains building automation systems

Task Descriptor

Building automation systems include integrated and environmental control systems.

Systems such as HVAC, fire alarm, lighting and security and other associated systems are interconnected through a building automation system that may signal or control the different building systems.

Building automation systems may also be integrated with automated control systems or may be stand alone. Building automation systems are also becoming integrated with personal communication devices.

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

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

E-28.01 Installs building automation systems

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

	Skills						
	Performance Criteria	Evidence of Attainment					
E-28.01.01P	determine type of building automation system required	type of building automation system is determined according to drawings, specifications, and job and facility requirements					
E-28.01.02P	determine <i>building automation system</i> layout	building automation system layout is determined according to drawings, specifications, location visit, and job and facility requirements					
E-28.01.03P	select building automation system components	building automation system components are selected according to drawings, specifications, and job and facility requirements					
E-28.01.04P	select tools and equipment	tools and equipment are selected according to task					
E-28.01.05P	position, mount and assemble building automation system components	building automation system components are positioned, mounted and assembled in locations according to drawings, specifications, and job and facility 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, specifications, and AHJ requirements					

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 are tested and have no opens, and all <i>building automation system components</i> 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	remove and dispose of or recycle existing building automation system and building automation system components	building automation system and building automation system components are disposed of or recycled according to local codes and waste disposal requirements
E-28.01.11P	participate in startup, restart and commissioning	building automation system components are activated to trigger functionality of building automation system and associated systems
E-28.01.12P	update documentation	documentation is updated according to commissioning

building automation systems include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and direct digital control (DDC), computer control

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

associated systems include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, supervisory, SCADA, PLC

documentation includes: as-built drawings, panel schedules, commissioning documents, manufacturers' specifications

	Knowledge			
	Learning Outcomes	Learning Objectives		
E-28.01.01L	demonstrate knowledge of building automation systems and building automation system components , their characteristics, applications, operation and interconnection	identify types of building automation systems , and describe their characteristics, applications and operation		
		interpret information pertaining to building automation systems found on drawings and specifications		
		interpret standards pertaining to building automation systems		

		identify building automation system components, and describe their characteristics and applications
		describe types of associated systems that interconnect with building automation systems
		identify considerations and requirements for selecting <i>building automation</i> systems and <i>building automation</i> system components
E-28.01.02L	demonstrate knowledge of procedures to install <i>building automation systems</i> and <i>building automation system components</i>	identify tools and equipment used to install <i>building automation systems</i> and <i>building automation system components</i> , and describe their applications and procedures for use
		describe procedures to install building automation systems and building automation system components
		describe procedures for testing building automation systems and building automation system components
		describe procedures for commissioning and verification of building automation systems and building automation system components

building automation systems include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control building automation system components include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches associated systems include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, SCADA, PLC

E-28.02 Maintains building automation systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
E-28.02.01P	obtain detailed description of malfunction or maintenance requirements	malfunction issues and <i>information</i> are obtained from <i>facility sources</i> and documented			
E-28.02.02P	identify building automation system and building automation system components	building automation system and building automation system components are identified according to documentation			
E-28.02.03P	select tools and equipment	tools and equipment are selected according to task			
E-28.02.04P	test building automation system	building automation system is tested and system activation performed			
E-28.02.05P	evaluate test results	test results are evaluated using previous results, manufacturers' specifications and commissioning documentation			
E-28.02.06P	adjust building automation system components	building automation system components are adjusted to optimize performance			
E-28.02.07P	replace building automation system components	replacement of <i>building automation system components</i> is scheduled with facility and local monitoring station, and replacement components are tested and verified			
E-28.02.08P	update documentation	documentation is updated to reflect testing, inspections and maintenance performed			
E-28.02.09P	notify and explain system changes	system changes are explained to system operator			

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

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

building automation systems include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control building automation system components include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches documentation includes: maintenance logs, digital back-up logs, inspection reports, as-built drawings, panel schedules, location log, commissioning documents, manufacturers' specifications

	Knov	vledge
	Learning Outcomes	Learning Objectives
E-28.02.01L demonstrate knowledge of <i>building</i> automation systems and <i>building</i> automation system components, their characteristics, applications, operation and interconnection		identify types of building automation systems , and describe their characteristics, applications and operation
		interpret information pertaining to building automation systems found on drawings and specifications, and manufacturer's documentation
		interpret standards pertaining to building automation systems
		identify <i>building automation system components</i> , and describe their characteristics and applications
		describe types of associated systems that interconnect with building automation systems
		identify considerations and requirements for selecting building automation systems and building automation system components
E-28.02.02L	demonstrate knowledge of procedures to maintain <i>building automation systems</i>	identify tools and equipment used to maintain <i>building automation systems</i> , and describe their applications and procedures for use
		describe procedures to maintain building automation systems and building automation system components

describe procedures for testing building automation systems, building automation system components and cables
describe procedures for commissioning and verification of building automation systems

building automation systems include: wireless, environmental control, integrated control, energy management, security and surveillance systems, pneumatic, analog electrical and DDC, computer control **standards** include: American National Standards Institute (ANSI)/ASHRAE 135 (BACnet), UL 916, ANSI/ Telecommunications Industry Association (TIA) 862

building automation system components include: network cabling, sensors (occupancy, light levels, humidity, temperature, level/float, pressure differential, digital, analog), servers, PoE switches, GUIs, damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches associated systems include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems, HVAC, lighting, communication systems, Internet, energy management system, SCADA, PLC

cables include: fibre optic, category/structure (category 5e, 6, 6A, 8), coaxial, twisted pairs, extra-low-voltage (LVT, ELC), shielded pairs, tri-ads, quads

Major Work Activity F

Installs and maintains process control systems

Task F-29 Installs and maintains input/output (I/O) devices

Task Descriptor

I/O devices are used in control systems. There may be discrete or analog devices. Industrial electricians must be able to install, maintain and upgrade these devices.

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

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

F-29.01 Installs discrete input/output (I/O) devices

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

	Skills			
	Performance Criteria	Evidence of Attainment		
F-29.01.01P	visually inspect equipment to be installed	equipment to be installed is checked for damage and nameplate data matches drawings		
F-29.01.02P	locate discrete I/O devices	discrete I/O devices are located by reading and interpreting prints, manufacturers' specifications, manuals and codes		
F-29.01.03P	select tools and equipment	tools and equipment are selected according to application, manufacturers' specifications and compatible components		
F-29.01.04P	mount discrete 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 drawings, manufacturers' specifications, facility requirements and codes
F-29.01.06P	ensure polarity of conductors to field devices	polarity of conductors to field devices is ensured using multimeter, plans and manufacturers' specifications
F-29.01.07P	ensure calibration parameters match external devices	calibration parameters match installation requirements of external devices
F-29.01.08P	commission discrete 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 facility policy
F-29.01.10P	update documentation	documentation is updated to reflect changes carried out

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

output (O) devices include: solenoid valves, relays, indicator light

methods include: bolting, welding, threading

	Knowledge				
	Learning Outcomes	Learning Objectives			
F-29.01.01L	demonstrate knowledge of <i>discrete</i> control devices, their characteristics, applications and operation	identify hazards and describe safe work practices pertaining to installation of discrete control devices			
		interpret information pertaining to discrete control devices found on drawings and specifications			
		explain use of discrete versus analog devices			
		identify types of <i>discrete control devices</i> and describe their characteristics, applications and operation			
		identify discrete control device components and accessories, and describe their characteristics and applications			
		identify types of <i>voltage used with discrete devices</i> , and describe its characteristics, applications and operation			
		explain use of discrete control devices for measurement			

		identify considerations and requirements for selecting <i>discrete control devices</i> , their components and accessories
F-29.01.02L	demonstrate knowledge of procedures to install, connect and calibrate <i>discrete control devices</i> , and their components and accessories	identify tools and equipment used to install, connect and calibrate <i>discrete control devices</i> , and their components and accessories, and describe their applications and procedures for use
		describe procedures to install, connect and set <i>discrete control devices</i> , and their components and accessories
		describe procedures to calibrate <i>discrete</i> control devices

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/0) devices

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

	Skills							
	Performance Criteria	Evidence of Attainment						
F-29.02.01P	select tools and equipment	tools and equipment are selected according to task						
F-29.02.02P	detect defects in discrete I/O device	defects in I/O device are detected by monitoring controller						
F-29.02.03P	perform sensory inspection of components	components are inspected for damage, wear, misalignment and loose connection according to scheduled maintenance requirements						
F-29.02.04P	review and analyze trends from discrete <i>I/O device</i> signal	trends from discrete I/O device signal are reviewed and analyzed to verify integrity of signal						
F-29.02.05P	check and set power supply voltages	power supply voltages are checked and set according to plans and manufacturers' specifications						
F-29.02.06P	calibrate discrete I/O devices	discrete I/O devices are calibrated according to drawings, manufacturers' specifications and facility requirements, and documented as found or as left						

F-29.02.07P	perform I/O function test on discrete device	I/O function test is performed on discrete device for verifying operation according to plans and manufacturers' specifications
F-29.02.08P	verify operation of discrete I/O devices	operation of <i>discrete I/O device</i> is verified following maintenance according to process parameters
F-29.02.09P	update documentation	documentation is updated to reflect changes carried out

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

 $\textbf{\textit{input (I) devices}} \ \text{include: pressure, proximity, level, motion, flow, temperature, vibration switches,}$

stop/start stations

output (O) devices include: solenoid valves, relays, indicator light

components for inspection include: limit switches, photocells, transmitters

discrete I/O devices include: pressure, proximity, level, motion, flow, temperature, vibration switches, stop/start station

	Knowledge							
	Learning Outcomes	Learning Objectives						
F-29.02.01L	demonstrate knowledge of <i>discrete</i> control devices, their characteristics, applications and operation	identify hazards and describe safe work practices pertaining to <i>discrete control devices</i>						
		interpret information pertaining to discrete control devices found on drawings and specifications						
		explain use of discrete versus analog devices						
		identify types of <i>discrete control devices</i> , and describe their characteristics, applications and operation						
		identify discrete control device components and accessories, and describe their characteristics and applications						
		identify type of <i>voltage used with discrete devices</i> , and describe its characteristics, applications and operation						
		explain use of discrete control devices for measurement						
		identify considerations and requirements for selecting <i>discrete control devices</i> , their components and accessories						

F-29.02.02L	demonstrate knowledge of procedures to maintain and test <i>discrete control devices</i> , their components and accessories	identify tools and equipment used to maintain and test <i>discrete control devices</i> , their components and accessories, and describe their applications and procedures for use		
		describe procedures to maintain <i>discrete control devices</i> , their components and accessories		
		describe procedures to repair and test discrete control devices, their components and accessories		

discrete control devices include: on-off control, counters and totalizers, timers, relays, pressure, temperature, level, flow

voltage used with discrete device includes: DC or AC voltage

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

F-29.03 Installs analog input/output (I/O) devices

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

	Skills						
	Performance Criteria	Evidence of Attainment					
F-29.03.01P	visually inspect equipment to be installed	equipment to be installed is checked for damage and nameplate data matches drawings					
F-29.03.02P	locate analog I/O devices	analog I/O devices are located by reading and interpreting prints, manufacturers' manuals and codes					
F-29.03.03P	select tools and equipment	tools and equipment are selected according to application, manufacturers' specifications and compatible components					
F-29.03.04P	mount <i>I/O devices</i>	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' specifications, and facility and CEC requirements					
F-29.03.06P	ensure polarity of conductors to field devices	polarity of conductors to field devices is ensured using multimeter, plans and manufacturers' specifications					

F-29.03.07P	configure device	device is configured by setting range according to plans and manufacturers' specifications
F-29.03.08P	ensure calibration parameters for external devices	calibration parameters are matched to installation requirements
F-29.03.09P	calibrate analog device	analog device is calibrated according to plans and manufacturers' specifications
F-29.03.10P	commission analog devices, and modify settings	analog devices are commissioned and settings are modified according to plans and manufacturers' specifications
F-29.03.11P	produce as-built drawings	as-built drawings are produced according to field installation and facility policy
F-29.03.12P	update documentation	documentation is updated to reflect changes carried out

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

output (O) devices include: proportional valves, linear actuators, solenoid valves

methods include: bolting, welding, threading

	Knowledge							
	Learning Outcomes	Learning Objectives						
F-29.03.01L	demonstrate knowledge of analog control devices , their characteristics, applications and operation	identify hazards and describe safe work practices						
		interpret information found on drawings and specifications						
		differentiate between use of analog versus discrete devices						
		identify types of 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 <i>signals used with analog devices</i> , and describe their characteristics, applications and operation						
		explain use of analog control devices for measurement						
		identify considerations and requirements for selecting analog control devices , their components and accessories						

F-29.03.02L	demonstrate knowledge of procedures to install, connect and calibrate <i>analog</i> control devices	identify tools and equipment used to install, connect and calibrate <i>analog control devices</i> , and describe their applications and procedures for use
		describe procedures to install and connect analog control devices, their components and accessories
		describe procedures to calibrate <i>analog</i> control devices

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/0) devices

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

	Skills							
	Performance Criteria	Evidence of Attainment						
F-29.04.01P	perform sensory inspection of components	components are inspected for damage, wear, misalignment and loose connection						
F-29.04.02P	select tools and equipment	tools and equipment are selected according to task						
F-29.04.03P	detect <i>defects</i> in analog <i>I/O device</i>	defects in I/O device are detected by monitoring controller according to repair request or scheduled maintenance						
F-29.04.04P	review and analyze trends from input device signal	trends from input device signal are reviewed and analyzed to verify integrity of signal						
F-29.04.05P	calibrate analog <i>I/O devices</i>	analog I/O devices are calibrated according to drawings, manufacturers' specifications and facility requirements, and document as found/as left						
F-29.04.06P	verify operation of analog <i>I/O devices</i>	operation of analog I/O devices is verified following service according to process parameters						
F-29.04.07P	update maintenance log	maintenance log is updated to reflect tasks performed						

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

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

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

output (O) devices include: proportional valves, linear actuators, solenoid valves

	Knowledge							
	Learning Outcomes	Learning Objectives						
F-29.04.01L	demonstrate knowledge of analog control devices , their characteristics, applications and operation	identify hazards and describe safe work practices						
		interpret information found on drawings and specifications						
		differentiate between use of analog versus discrete devices						
		identify types of 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 <i>signals used with analog devices</i> , and describe their characteristics, applications and operation						
		explain use of analog control devices for measurement						
		identify considerations and requirements for selecting <i>analog control devices</i> , their components and accessories						
F-29.04.02L	demonstrate knowledge of procedures to maintain and test <i>analog control devices</i> , their components and accessories	identify tools and equipment used to maintain and test <i>analog control devices</i> , their components and accessories, and describe their applications and procedures for use						
		describe procedures to maintain <i>analog control devices</i> , their components and accessories						
		describe procedures to test <i>analog control devices</i> , their components and accessories						

analog control devices include: pressure, proximity, level, motion, flow, temperature and vibration transmitters, proportional valves, linear actuators, solenoid valves, transducers
 signals used with analog devices include: resistance, current, voltage (sinking or sourcing)

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

Task Descriptor

In industrial, manufacturing or utility environments, processes require control and the ability to interface with other systems. These controls can be complex automated systems. Automated control systems are often programmable systems such as PLC and DCS.

The operator interfaces for many of these systems have migrated from physical hardware to GUI such as HMIs. As a result, the electrical work pertaining to the I/O devices has become software based.

Automated control systems may also be integrated with Building Automation Systems.

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

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

F-30.01 Installs automated control systems

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

	Skills						
	Performance Criteria	Evidence of Attainment					
F-30.01.01P	determine type and function of automated control system	automated control system is selected according to application					
F-30.01.02P	calculate conductor and cabling requirements	conductor and cable type and size are calculated according to application, codes and manufacturers' specifications					
F-30.01.03P	select tools and equipment	tools and equipment are selected according to task					
F-30.01.04P	position, mount and assemble automated control system	automated control system is positioned, mounted and assembled in locations according to drawings, and job and facility requirements; is level, square, and secure, and follows building lines					

F-30.01.05P	configure automated control systems hardware	automated control system hardware is configured by ensuring dip switches, keying and jumpers are in required position according to drawings and manufacturers' specifications
F-30.01.06P	bond automated control systems	automated control systems are bonded according to codes and manufacturers' specifications
F-30.01.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, manufacturers specifications, and AHJ, CSA and CEC requirements
F-30.01.08P	set up and adjust automated control systems	automated control systems are set up and adjusted according to CEC requirements, application and intended function
F-30.01.09P	interconnect and configure automated control systems with peripheral devices	 automated control systems are interconnected with peripheral devices and equipment functions as intended
F-30.01.10P	test automated control systems after installation	automated control systems are connected and function according to manufacturers' specifications and facility requirements, and results are documented
F-30.01.11P	update documentation	operational changes are reflected in drawings following removal or replacement of equipment which is performed with minimal impact to environment

automated control systems include: PLC, SCADA system, DCS, DNP peripheral devices of automated control systems include: HMI (touchscreen and discrete buttons), displays, keyboard, mouse, printers

	Knowledge						
	Learning Outcomes	Learning Objectives					
F-30.01.01L	demonstrate knowledge of automated control systems and automated control system components, their characteristics, applications, operation and interconnections	identify types of automated control systems , and describe their characteristics, applications, operation and interconnections					
		identify <i>automated control system components</i> , 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 <i>automated control system</i> installation, configuration and programming
		identify <i>number systems</i> and <i>code systems</i> , and describe their applications
		perform conversions between <i>number</i> systems
		explain and interpret control circuit logic
F-30.01.02L	demonstrate knowledge of automated control system data communication systems and automated control system components	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 devices used to communicate with interconnected automated control systems
F-30.01.03L	demonstrate knowledge of procedures to install and connect automated control systems and automated control system components	identify tools and equipment used to install and connect automated control systems and automated control system components, and describe their applications and procedures for use
		describe procedures to install automated control systems and automated control system components
		describe procedures to connect automated control systems and automated control system components

automated control systems include: PLC, SCADA system, DCS, DNP

automated control system components include: hardware (power supply, central processing unit [CPU], I/O system, programming terminals), software

number systems include: binary, decimal, hexadecimal, octal

code systems include: binary coded decimal (BCD), American Standard Code for Information Interchange (ASCII)

control circuit logic includes: relay logic, ladder logic, function block, text based

automated control system data communication systems include: Ethernet, Modbus, Profibus,

BACnet, Fieldbus, DeviceNet, ControlNet, IEC

devices include: handheld mobile (tablet), computer, HMI

F-30.02 Maintains automated control systems

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

	Skills								
	Performance Criteria	Evidence of Attainment							
F-30.02.01P	obtain detailed description of operation and malfunction or scheduled maintenance requirements	operation, malfunction issues and information are obtained from facility sources and documented							
F-30.02.02P	select tools and equipment	tools and equipment are selected according to task							
F-30.02.03P	determine source of malfunction	source of malfunction is determined according to <i>field assessments</i> and <i>diagnostic and test equipment</i> results							
F-30.02.04P	identify and remove defective components	defective components are removed without damage to system or other components							
F-30.02.05P	repair and test malfunctioning components	components are repaired and tested according to manufacturers' specifications							
F-30.02.06P	select replacement components	OEM or equivalent replacement components are selected							
F-30.02.07P	install replacement components	OEM or equivalent replacement components are installed with minimal disruptions and interruptions, and according to manufacturers' specifications and facility policy							
F-30.02.08P	conduct tests of automated control systems	automated control systems are tested after repair, connected and function according to manufacturers' specifications and facility requirements							
F-30.02.09P	inspect, clean and adjust components	automated control systems are inspected, cleaned and adjusted to restore to optimal conditions and according to manufacturers' specifications							
F-30.02.10P	complete backups and document tests in maintenance log	operational problems and test results are identified in maintenance log							
F-30.02.11P	archive and update firmware	firmware is archived and updated according to manufacturers' specifications and facility requirements							
F-30.02.12P	compare and analyze maintenance test results	maintenance is performed according to analysis of test results and specifications							

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

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

field assessments include: sensory inspections, technical inspections

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

automated control systems include: PLC, SCADA system, DCS, DNP

inspect, clean and adjust includes: inspecting terminations, cleaning fans and filters, adjusting access openings and sealing, cleaning sensors

	Knowledge							
	Learning Outcomes	Learning Objectives						
F-30.02.01L	demonstrate knowledge of automated control systems and automated control system components, their characteristics, applications, operation and interconnections	identify types of <i>automated control systems</i> , and describe their characteristics, applications, operation and interconnections						
		identify automated control system components , and describe their purpose and operation						
		interpret information found on drawings and specifications						
		interpret codes and regulations pertaining to <i>automated control systems</i>						
		identify sources of information pertaining to <i>automated control system</i> service, maintenance, troubleshooting and configuration						
		identify <i>number</i> and <i>code systems</i> , and describe their applications						
		perform conversions between <i>number</i> systems						
		explain and interpret control circuit logic						
		describe basic Proportional-Integral- Derivative (PID) control theory						
		describe basic process control theory						
		identify basic instruction sets for ladder logic and basic function block , and describe their applications						
F-30.02.02L	demonstrate knowledge of automated control system data communication systems and their components	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 devices used to communicate with interconnected automated control systems
F-30.02.03L	demonstrate knowledge of procedures for maintenance of automated control systems and automated control system components	identify tools and equipment used to maintain automated control systems and automated control system components, and describe their applications and procedures for use
		describe procedures to maintain automated control systems and automated control system components

automated control systems include: PLC, SCADA system, DCS, DNP

automated control system components include: hardware (power supply, CPU, I/O system,

programming terminals), software

number systems include: binary, decimal, hexadecimal, octal

code systems include: BCD, ASCII, gray code

control circuit logic includes: relay logic, ladder logic, function block

automated control system data communication systems include: Ethernet, Modbus, Profibus,

BACnet, Fieldbus, DeviceNet, IEC

devices include: handheld mobile (tablet), computer, HMI

basic instruction sets for ladder logic include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

basic function block includes: input block, control block and output block

basic process control theory includes: control loops, control modes, loop tuning

F-30.03 Programs automated control systems

NL	NS	PE	NB	QC	ON	МВ	SK	AB	ВС	NT	YT	NU
yes	yes	NV	yes	NV	yes	yes	ND	yes	yes	NV	NV	ND

	Skills					
	Performance Criteria	Evidence of Attainment				
F-30.03.01P	map <i>inputs and outputs</i>	inputs and outputs are mapped using manufacturers' software to meet process requirements				
F-30.03.02P	set address <i>variables</i>	address <i>variables</i> are set for internal instructions according to application				

F-30.03.03P	write or edit and verify automated control program	automated control program is written, edited and verified to operate according to specified logic				
F-30.03.04P	back-up and document program changes	program changes are backed-up and documented according to facility policy				
F-30.03.05P	set parameters for automated control program	technical and operating parameters are set according to installation and operation requirements				
F-30.03.06P	test and adjust automated control program	operation of system is tested and adjusted according to design and facility requirements				

inputs and outputs include: direct address, tag-based address *variables* include: timers, counters, blocks, registers, tables

	Kno	wledge
	Learning Outcomes	Learning Objectives
F-30.03.01L	demonstrate knowledge of automated control systems , their characteristics, applications, operation and interconnection	identify types of automated control systems , and describe their characteristics, applications, operation and interconnections
		explain differences between PLC and DCS systems
		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 <i>number systems</i> and <i>code systems</i> , and describe their applications
		perform conversions between <i>number</i> systems
		explain and interpret control circuit logic
		describe basic PID control theory
F-30.03.02L	demonstrate knowledge of automated control system data communication systems and their components	identify types of automated control system 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	identify devices used to communicate with interconnected automated control systems , and describe procedures to perform programming, editing and configuration of automated control systems online and offline
		identify automated control system programming languages and describe their applications

automated control systems include: PLC, SCADA system, DCS, DNP

automated control system data communication systems include: Ethernet, Modbus, Profibus,

BACnet, Fieldbus, DeviceNet, IEC

basic instruction sets for ladder logic include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

basic function block includes: input block, control block and output block

number systems include: binary, decimal, hexadecimal, octal

code systems include: BCD, ASCII, gray code

control circuit logic includes: relay logic, ladder logic, function block, text based

devices include: handheld mobile (tablet), computer, HMI

F-30.04 Optimizes system performance

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

	SI	kills
	Performance Criteria	Evidence of Attainment
F-30.04.01P	ensure version of manufacturers' manual matches version of manufacturers' software	version of manufacturers' software is matched to manufacturers' manual
F-30.04.02P	archive and update firmware	firmware is archived and updated to facilitate system operation according to manufacturers' specifications and facility requirements
F-30.04.03P	review and modify existing program and system parameters	program (machine cycle time and scan time) and system parameters are reviewed and modified to match changes of process, and to ensure efficiency of program
F-30.04.04P	ensure sequential programming logic	sequential programming logic is ensured to optimize scan time

F-30.04.05P	test run program	program is executed in test mode to verify intended operation and optimization
F-30.04.06P	tune control loops	control loops are tuned to optimize process
F-30.04.07P	back-up and document program changes	program changes are backed-up and documented according to facility policy

	Know	rledge
	Learning Outcomes	Learning Objectives
F-30.04.01L	demonstrate knowledge of automated control systems , their characteristics, applications and operation	identify types of automated control systems , and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to automated control systems
		identify <i>number systems</i> and <i>code systems</i> , and describe their applications
		perform conversions between <i>number</i> systems
		explain and interpret control circuit logic
		describe basic PID control theory
		describe basic process control theory
		identify basic instruction sets for ladder logic and basic function block , and describe their applications
F-30.04.02L	demonstrate knowledge of automated control system data communication systems and their components	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
F-30.04.03L	demonstrate knowledge of procedures for programming, configuring and optimizing automated control systems	identify devices used to communicate with interconnected automated control systems , and describe procedures to perform programming, editing, configuration, optimization and firmware updates of automated control systems online and offline
		identify automated control system programming languages and describe their applications

automated control systems include: PLC, SCADA system, DCS, DNP

automated control system components include: hardware (power supply, CPU, I/O system,

programming terminals), software

number systems include: binary, decimal, hexadecimal, octal

code systems include: BCD, ASCII, gray

control circuit logic includes: relay logic, ladder logic, function block, text based

automated control system data communication systems include: Ethernet, Modbus, Profibus,

BACnet, Fieldbus, DeviceNet, IEC

devices include: handheld mobile (tablet), computer, HMI

basic instruction sets for ladder logic include: examine-on (normally open contact) and examine-off (normally closed contact), output, timers, counters, sequencers, shift registers, block transfers, data registers

basic function block includes: input block, control block and output block

basic process control theory includes: control loops, control modes, loop tuning

Task F-31 Installs and maintains pneumatic and hydraulic control systems

Task Descriptor

Pneumatic and hydraulic equipment is used to supply energy and to control equipment and processes through the use of air, nitrogen, process gases and fluids. Industrial electricians install and maintain pneumatic and hydraulic control systems.

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

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

F-31.01 Installs pneumatic control systems

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

		Skills
	Performance Criteria	Evidence of Attainment
F-31.01.01P	determine location of pneumatic equipment	location of pneumatic equipment is determined according to plans, codes, facility policy and manufacturers' recommendations
F-31.01.02P	select tools and equipment	tools and equipment are selected according to task

F-31.01.03P	connect pneumatic control system components	pneumatic control system components are connected according to plans, codes and process requirements
F-31.01.04P	calibrate pneumatic control devices	pneumatic control <i>devices</i> are calibrated to process requirements
F-31.01.05P	verify operation of pneumatic control system	operation of pneumatic control system is verified by using test equipment and procedures to ensure it is within specified parameters
F-31.01.06P	update documentation	documentation is updated to reflect changes carried out

pneumatic control system components include: regulators, separators, tubing, actuators, solenoids, pumps, positioners, accumulators, compressors, tanks, coolers, filters, dryers, automated oilers devices include: pressure switches, regulators, gauges

	Know	rledge		
	Learning Outcomes	Learning Objectives		
F-31.01.01L	demonstrate knowledge of <i>pneumatic</i> control systems and <i>pneumatic</i> control system components, their characteristics, applications and operation	identify types of <i>pneumatic control</i> systems and <i>pneumatic control system</i> components, and describe their characteristics, applications and operation		
		interpret information pertaining to pneumatic control system devices found on drawings and specifications		
		interpret <i>documentation</i> to determine operation of pneumatic control systems		
F-31.01.02L	demonstrate knowledge of pneumatic related <i>calculations</i>	describe effects of and impacts of installation on pneumatic related calculations		
F-31.01.03L	demonstrate knowledge of procedures to install <i>pneumatic control system</i> equipment and <i>pneumatic control system components</i>	identify tools and equipment used to install <i>pneumatic control system</i> equipment and <i>pneumatic control system components</i> , and describe their applications and procedures for use		
		describe procedures to install <i>pneumatic</i> control systems and pneumatic control system components		

Range of Variables

pneumatic control systems include: instrument air, instrument gas

pneumatic control system components include: regulators, separators, tubing, actuators, solenoids, pumps, positioners, accumulators, compressors, tanks, coolers, filters, dryers, automated oilers

documentation includes: schematics, manufacturers' manuals

calculations include: signal conversion, unit conversion

F-31.02 Maintains pneumatic control systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
F-31.02.01P	select tools and equipment	tools and equipment are selected according to task			
F-31.02.02P	test and verify control devices	control devices are tested and verified according to system specifications			
F-31.02.03P	calibrate and adjust control devices	control devices are calibrated and adjusted according to system specifications and maintenance schedules			
F-31.02.04P	change system <i>components and materials</i>	system <i>components and materials</i> are changed according to manufacturers' specifications and facility policy			
F-31.02.05P	identify probable root cause and location of faults	probable root cause and location of faults are identified using diagnostic tools and testing procedures, speaking with <i>facility sources</i> and using maintenance documentation and historical data			
F-31.02.06P	determine steps required to repair faults and address deficiencies	steps required to repair faults and address deficiencies are determined based on results of root cause analysis			
F-31.02.07P	lock out and de-energize energy potential	lockout and de-energization are verified by performing a post-operational test to verify zero energy state and gravity (kinetic)			
F-31.02.08P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures			
F-31.02.09P	verify operation	operation is verified before returning to service			
F-31.02.10P	document changes	changes are documented according to facility policy			

Range of Variables

system specifications include: pressure, flow

components and materials include: filters, drying systems, reservoirs, compressors

 $\textit{facility sources} \ (\text{for information}) \ \text{include: operators, maintenance personnel, supervisors, work order,} \\$

other trades

	Knowledge			
	Learning Outcomes	Learning Objectives		
F-31.02.01L	demonstrate knowledge of pneumatic control systems and their components, applications and operation	interpret information found on drawings and specifications		
		identify types of <i>pneumatic control</i> systems and their components, and describe their applications and operation		
		interpret <i>documentation</i> to determine operation of pneumatic control systems		
F-31.02.02L	demonstrate knowledge of pneumatic related <i>calculations</i>	describe effects of and impacts of maintenance on pneumatic related calculations		
F-31.02.03L	demonstrate knowledge of procedures to maintain <i>pneumatic control systems</i> and their components	identify tools and equipment used to maintain <i>pneumatic control systems</i> and their components, and describe their applications and procedures for use		
		describe procedures to maintain pneumatic control systems and their components		

pneumatic control systems include: instrument air, instrument gas documentation includes: schematics, manufacturers' manuals calculations include: signal conversion, unit conversion

F-31.03 Installs hydraulic control systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
F-31.03.01P	select hydraulic system control devices and hydraulic control system components	hydraulic system control devices and hydraulic control system components are selected according to manufacturers' specifications, process requirements and codes			
F-31.03.02P	select tools and equipment	tools and equipment are selected according to task			
F-31.03.03P	determine location of <i>hydraulic system</i> control devices	location of <i>hydraulic system control devices</i> is determined according to codes, practices and manufacturers' recommendations			

F-31.03.04P	connect hydraulic system control devices and hydraulic control system components	hydraulic system control devices and hydraulic control system components are connected using materials
F-31.03.05P	verify operation of hydraulic equipment and hydraulic system control devices	operation of hydraulic equipment and hydraulic system control devices are verified using test equipment and procedures to ensure they are within specified parameters
F-31.03.06P	update documentation	documentation is updated to reflect changes carried out

hydraulic system control devices include: solenoids, switches, actuators
hydraulic control system components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

	Knowledge				
	Learning Outcomes	Learning Objectives			
F-31.03.01L	demonstrate knowledge of hydraulic control systems and <i>hydraulic control</i> system components, their applications and operation	identify types of hydraulic control systems and <i>hydraulic control system components</i> , and describe their applications and operation			
		interpret information pertaining to hydraulic system control devices found on drawings and specifications			
		interpret <i>documentation</i> to determine operation of hydraulic control systems			
	demonstrate knowledge of procedures to install hydraulic control systems and hydraulic control system components	identify tools and equipment used to install hydraulic control systems and hydraulic control system components, and describe their applications and procedures for use			
		describe procedures to install hydraulic control systems and hydraulic control system components			

Range of Variables

documentation includes: schematics, manufacturers' manuals

hydraulic control system components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

F-31.04 Maintains hydraulic control systems

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

	Skills				
	Performance Criteria	Evidence of Attainment			
F-31.04.01P	select tools and equipment	tools and equipment are selected according to task			
F-31.04.02P	test and verify hydraulic system control devices and hydraulic control system components	hydraulic system control devices and hydraulic control system components are tested and verified according to system specifications			
F-31.04.03P	calibrate and adjust hydraulic system control devices and hydraulic control system components	hydraulic system control devices and hydraulic control system components are calibrated and adjusted according to system specifications and maintenance schedules			
F-31.04.04P	check fluid and filters	fluids and filters are checked according to manufacturers' specifications			
F-31.04.05P	change hydraulic control system components	hydraulic control system components are changed according to manufacturers' specifications and facility policy			
F-31.04.06P	identify probable root cause and location of faults	probable root cause and location of faults are identified using diagnostic tools and testing procedures, and referring to maintenance documentation and historical data			
F-31.04.07P	determine steps required to repair faults and address deficiencies	steps required to repair faults and address deficiencies are determined according to results of root cause analysis			
F-31.04.08P	lock out and de-energize energy potential	lockout and de-energization are verified by performing a post-operational test to verify zero energy state and gravity (kinetic)			
F-31.04.09P	remove, repair or replace faulty components	faulty components are removed, repaired or replaced by using prescribed methods and procedures			
F-31.04.10P	verify operation	operation is verified before returning to service			
F-31.04.11P	update maintenance log	maintenance log is updated to reflect tasks performed			

hydraulic system control devices include: solenoids, switches, actuators system specifications include: pressure, flow, temperature, level

hydraulic control system components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

	Knowledge				
	Learning Outcomes	Learning Objectives			
F-31.04.01L	demonstrate knowledge of hydraulic control systems and <i>hydraulic control</i> system components, their applications and operation	identify types of hydraulic control systems and <i>hydraulic control system components</i> , and describe their applications and operation			
		interpret information pertaining to hydraulic system control devices found on drawings and specifications			
		interpret documentation to determine operation of hydraulic control systems			
F-31.04.02L	demonstrate knowledge of procedures to maintain hydraulic control system equipment and hydraulic control system components	identify tools and equipment used to maintain hydraulic control system equipment and <i>hydraulic control system components</i> , and describe their applications and procedures for use			
		describe procedures to maintain hydraulic control systems and hydraulic control system components			

Range of Variables

hydraulic control system components include: accumulators, pumps, tanks, coolers, filters, reservoirs, tubing, hoses, fittings, snubbers, pressure gauges, thermometers, fluids

hydraulic system control devices include: solenoids, switches, actuators

documentation includes: schematics, manufacturers' manuals

APPENDIX A

ACRONYMS

AC alternating current

AED automated external defibrillator

AFCI arc fault circuit interrupter
AHJ authority having jurisdiction

ANSI American National Standards Institute

ASCII American Standard Code for Information Interchange

AVR Automatic Voltage Regulator

BCD binary coded decimal
BIL Basic Insulation Level
CAD computer-aided design

CAM computer-aided manufacturing

CCTV closed-circuit television
CEC Canadian Electrical Code
CPR cardiopulmonary resuscitation

CPU central processing unit

CSA Canadian Standards Association
CSC Construction Specifications Canada

CT current transformer

DAS distributed antenna system

DC direct current

DCLA data communication link, Class A
DCLB data communication link, Class B
DCLC data communication link, Class C

DCS distributed control system

DDC direct digital control

DNP distributed network protocol

DVR digital video recorder ELV extra-low-voltage

EMC electro-magnetic compatibility
EMT electrical metallic tubing

ENT electrical non-metallic tubing

FLC full load current

GFCI ground fault circuit interrupter

GUI graphical user interface
HDPE high-density polyethylene
HID high intensity discharge

HMI human machine interfacing

HVAC heating, ventilation and air-conditioning

I/O input/output

IEEE Institute of Electrical and Electronics Engineers

IP Ingress Protection kVA kilovolt-amps

LAN local area network
LED light emitting diode
MCC motor control centre
MOV metal oxide varistor
NBC National Building Code

NFC National Fire Code of Canada

O&M operations and maintenance

OEM original equipment manufacturer

OH&S Occupational Health and Safety

OTDR optical time-domain reflectometer

PA public address

PCB polychlorinated biphenyl PDC power distribution centre

PID proportional-integral-derivative PLC programmable logic controller

PoE Power over Ethernet

PPE personal protective equipment

PVC Poly Vinyl Chloride

RFID radio frequency identification

ScTP screened twisted pair

SIS safety instrumented systems

SCADA Supervisory Control and Data Acquisition

SDS Safety Data Sheets

TDR time-domain reflectometer

TIA Telecommunications Industry Association

SPL sound pressure level SI système internationale

TDG Transportation of Dangerous Goods
ULC Underwriters Laboratories of Canada

UPS uninterruptible power supply

UTP unshielded twisted pair

VA volt-ampere VDV voice/data/video

VFD variable frequency drive
VoIP voice over Internet protocol

VT voltage transformer (previously called potential transformer)

WHMIS Workplace Hazardous Materials Information System

WLL working load limit

APPENDIX B

TOOLS AND EQUIPMENT / OUTILS ET ÉQUIPEMENT

Hand Tools / Outils à main

adjustable wrenches clés ajustables

cable cutters (ratchet) coupe-câbles (à rochet)

cable splice/stripper tools outils à épisser et à dénuder les câbles

cable tie guns pistolets pour attache-câbles

calculators calculatrices

centre punches pointeaux à centrer

chisels ciseaux

cold chisels ciseaux à froid crimping pliers pinces à sertir

diagonal cutting pliers pinces à coupe diagonale

drill bits (auger, masonry, step and wood) forets (hélicoïdaux, de maçonnerie, étagés et à bois)

files limes

fish tapes ruban de tirage flashlights lampes de poche fuse pullers arrache-fusibles hacksaws scies à métaux

hammers (ball pein, dead blow and rubber) marteaux (à panne ronde, à amortisseur et en caoutchouc)

hex keys (metric/imperial) clés hexagonales (métriques et impériales)

hole saws scies emporte-pièces hot sticks perches isolantes

integrated circuit extractors extracteurs pour circuits intégrés jumpers cables/wires câbles survolteurs et câbles de liaison

keyhole saws scies à guichet

knives couteaux

knock-out cutters emporte-pièces

levels including torpedo niveaux, y compris les niveaux à torpille

linesman pliers pinces d'électricien

cable/wire pullers tire-câbles

needle nose pliers pinces à bec effilé
nipple chucks mandrins à mamelons

nut drivers (metric/imperial) tournevis à douille (métriques et impériaux)

picks pioches

pipe benders and hickeys plieuses à tuyaux et cintreuses

pipe cutters coupe-tuyaux

pipe reamers (hand and ratchet) alésoirs à tuyaux (à main et à rochet)

pipe threaders fileteuses de tuyaux

pipe wrenches clés à tuyaux punches poinçons

PVC cutters ciseaux pour le PVC

scrapers grattoirs screw starters pose-vis

screwdrivers (flat, phillips, robertson and

torx)

tournevis (plats, cruciformes, à pointe carrée et Torx)

scribes pointes à tracer

side cutters ciseaux à coupe latérale

slide lock pliers pinces réglables

socket sets (metric/imperial) jeux de douilles (métriques et impériales)

spline keys clavettes

static discharge wristbands and anti-static

mats

bracelets antidécharge d'électricité statique et tapis

antistatiques

step drills forets étagés tape measures rubans à mesurer

taps (metric/imperial) and dies tarauds (métriques et impériaux) et matrices

telescopic magnets aimants télescopiques telescopic mirrors miroirs télescopiques tin snips cisailles de ferblantier

torches (butane, propane, oxy-acetylene) chalumeaux (au butane, au propane et oxyacétyléniques)

tri-tap tools outils de taraudage triples

trouble lights lampes baladeuses

vice grip pliers pinces-étaux

water pump pliers (tongue-and-groove pliers) pinces multiprises (pinces de plombier)

wire strippers pinces à dénuder les fils

wood saws scies à bois

wrenches (metric/imperial) clés (métriques et impériales)

Portable Power Tools / Outils mécaniques portatifs

band saws scies à ruban cable tuggers tire-câbles

circular saws scies circulaires

crimping tools (hydraulic/electric) outils à sertir (hydrauliques et électriques)

cut-off saws tronçonneuses
drills perceuses
grinders rectifieuses

hammer drills marteaux perforateurs

heat guns pistolets à air chaud

hydraulic benders plieuses de tuyaux hydrauliques

hydraulic crimpers sertisseurs hydrauliques hydraulic knock-out punches emporte-pièces hydrauliques

impact guns clés à chocs jig saws scies sauteuses

magnetic base drill presses perceuses à colonne à base magnétique

pipe threading machines machines à fileter les tuyaux power pipe benders plieuses de tuyaux mécaniques

PVC conduit heaters appareils de chauffage de tuyaux en PVC

reciprocating saws scies alternatives soldering equipment machines de soudage

Powder-Actuated Tools / Outils à charge explosive

exothermic welding equipment machines de soudage exothermique

powder-actuated fastening tools fixateurs à charge explosive

Stationary Power Tools / Outils mécaniques fixes

band saws scies à ruban

bearing heaters réchauffeurs de roulements
belt sanders ponceuses à courroie
bench grinders meuleuses d'établi
buffers meules de finition
chop saws scies à onglets

drill presses perceuses à colonne

hydraulic power units blocs d'alimentation hydrauliques

hydraulic presses presses hydrauliques

parts washers machines à laver les pièces

portable grinders meuleuses portatives

sand blasters décapeuses par jet de sable

threading machines fileteuses

under cutting machines machines à entailler

Communication and Fibre Optic Tools / Outils pour câbles à fibres optiques et de télécommunications

cleavers couteaux à fibre optique inspection scopes caméras d'inspection

fusion splicers fusionneuses

optical time-domain reflectometers (OTDR) réflectomètres optiques dans le domaine temporel

optical power meters and light sources wattmètres optiques et sources de lumière

polishing pucks rondelles de polissage

swivels/fuses émerillons et fusibles

coaxial strippers and crimpers outils à dénuder les câbles coaxiaux et sertisseuses de

câbles coaxiaux

scissors ciseaux

voice/data crimp tools outils à sertir les câbles de transmission voix-données voice/data punch down tools enrouleurs de câbles de transmission voix-données

time-domain reflectometers (TDR) réflectomètres dans le domaine temporel

Electrical Test and Diagnostic Equipment / Appareils électriques de diagnostic et de vérification

chart recorders enregistreurs graphiques
circuit tracers dépisteurs de circuits
clamp-on ammeters pinces ampèremétriques
conductivity testers vérificateurs de conductivité

contact resistance meters mesureurs de la résistance de contact

frequency meters fréquencemètres
Geiger counters compteurs Geiger

ground fault finders détecteurs de fuites à la terre hipot testers vérificateurs de rigidité diélectrique

instrumentation loop calibrators étalonneurs de boucles pour les instruments

insulation resistance testers vérificateurs de résistance d'isolement (mégohmmètres)

(megohmmeters/meggers)

laptop computers and software ordinateurs portables et logiciels light meters (light intensity) luxmètres (lampes témoins)

multimeters multimètres

network analyzers analyseurs de réseaux

non-contact voltage testers vérificateurs de tension sans contact

oscilloscopes oscilloscopes

panel meter calibrators étalonneurs de panneau de mesure phase sequence testers vérificateurs d'ordre des phases

potential testers vérificateurs de potentiel

pressure calibration pumps pompes d'étalonnage de la pression

signal generators générateurs de signaux

sound level meters décibelmètres

temperature guns thermomètres infrarouges thermal graphic cameras caméras thermiques thermal graphic equipment appareils thermiques

timers minuteries

voltage testers vérificateurs de tension Wheatstone bridges ponts de Wheatstone

Mechanical Measuring Instruments and Devices / Appareils et dispositifs de mesure mécaniques

dial indicators indicateurs à cadran

distance measuring wheels roues de mesure de distance

feeler gauges (metric/imperial) jauges d'épaisseur

hydrometers hydromètres micrometers micromètres pressure gauges manomètres

protractors rapporteurs d'angle

shaft alignment tools (dial and laser) outils d'alignement d'arbres (à cadran et à laser)

tachometers tachymètres

torque wrenches clés dynamométriques vernier calipers pieds à coulisse à vernier

vibration sensors (accelerometer, velocity, capteurs de vibrations (accéléromètres, capteurs de vitesse,

proximity) capteurs de proximité)

Rigging, Tugging, Hoisting, Lifting Material / Matériel de gréage, de tirage, de hissage et de levage

articulated boom lifts élévateurs à flèche articulée

beam clamps attaches de poutre block and tackle palans à moufles

cable pullers (hand or electric powered) tire-câbles (manuels ou électriques) cable pulling grips (wire mesh grips) tire-câbles en treillis métallique

chain fall/come-along palans à chaîne et palans manuels à levier

hoists treuils

jack stands supports de sécurité lifting eyes anneaux de levage platform lifts plateformes élévatrices pulleys (hook sheaves) poulies (à crochet)

ropes cordes

scissor lifts plateformes élévatrices à ciseaux

shackles manilles slings (nylon and wire) élingues

strain relief réducteurs de tension

tray rollers rouleaux pour chemin de câbles

tow motors/fork lifts chariots tracteurs et chariots élévateurs à fourche

Scaffolding and Access Equipment / Échafaudages et appareils et dispositifs d'accès

aerial work platforms (AWPs) nacelles élévatrices extension ladders échelles à coulisse

man baskets nacelles

platform lifts plateformes élévatrices

portable stairs marchepieds scaffolds échafaudages

scissor lift plateformes élévatrices à ciseaux

step ladders escabeaux

Personal Protective Equipment and Safety Equipment / Équipement de protection individuelle et équipement de sécurité

air packs appareils respiratoires Air-Pak

anchor slings (cable and nylon) élingues d'ancrage (à câble et en nylon)

arc flash PPE's équipement de protection individuelle contre les arcs

électriques

breaker locks (multi-lock, lock box, lock tag) dispositifs de cadenassage de disjoncteur (multipolaires,

boîtiers de sécurité et étiquettes cadenas)

carabiners mousquetons

dust masks masques antipoussières

ear protectors (muffs and plugs) protège-oreilles (bouche-oreilles et casques antibruits)

emergency eyewash equipment douches oculaires d'urgence

face shields écrans faciaux

fall arrest equipment dispositifs antichutes

fall restraint equipment dispositifs de retenue en cas de chute

fire extinguishers extincteurs

fire retardant clothing vêtements ignifugés

first aid equipment trousses de premiers soins

fume and toxic gas detectors détecteurs de vapeurs et de gaz toxiques

grounding sticks perches de mise à la terre hard hats casques de protection harnesses (full body) harnais (complets) vestes réfléchissantes

high-voltage gloves (insulated) gants de protection contre la haute tension (isolés)

high-voltage test equipment vérificateurs de haute tension

hot gloves gants isolants
hot pads tapis isolants
hot sticks perches isolantes
knee pads protecteurs de genoux

lanyards (energy absorbing and twin leg) longes de sécurité (amortisseuses et doubles) low-voltage gloves (insulated) gants de protection contre la basse tension (isolés)

protective aprons tabliers de protection

protective gloves/gauntlets gants et gantelets de protection

respirators (full-face and half-mask) respirateurs (masques complets et demi-masques)

rope grabs coulisseaux de sécurité

Self-Contained Breathing Apparatus (SCBA)

safety footwear

safety glasses/goggles self-retracting lifelines

signage

temporary protective ground equipment

welding gloves

welding helmets/masks

appareils de protection respiratoire autonomes

chaussures de sécurité

lunettes de sécurité et lunettes à coque câbles de sécurité autorétractables

panneaux d'avertissement

conducteurs de mise à la terre de protection temporaire

gants de soudeur

casques et masques de soudeur

APPENDIX C

GLOSSARY / GLOSSAIRE

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 orientation and size of the conductors	arc électrique	décharge électrique à très haute température causée par un défaut d'origine électrique dans l'air qui se produit sur un appareil sous tension en raison d'une connexion à faible impédance reliant la terre ou un autre conducteur de phase dans un réseau électrique. L'intensité de la décharge dépend de la puissance de la source d'énergie et du sens et de la grosseur des conducteurs.
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	liaison par continuité des masses	liaison de faible impédance réalisée en reliant de façon permanente toutes les pièces métalliques non porteuses de courant dans le but d'assurer une continuité électrique; cette liaison doit pouvoir acheminer, en toute sécurité, tout courant susceptible de la parcourir.
cable	a complete manufactured assembly of one or more insulated conductors, optical fibres, or both which may have fillers, strength members, and insulating and protective material, and may also have a continuous overall covering providing a degree of electrical, mechanical and environmental protection to the assembly	câble	assemblage constitué d'au moins un conducteur isolé ou de fibres optiques, ou des deux, qui pourraient comprendre du remplissage, des éléments de renforcement et des matériaux isolants et de protection, et qui pourrait comprendre aussi une enveloppe continue assurant une certaine protection électrique, mécanique et environnementale de l'ensemble.
cathodic protection	protection technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell	protection cathodique	technique de protection utilisée pour empêcher la corrosion d'une surface métallique en rendant cette surface la cathode d'une cellule électrochimique.
commissioning	initial startup of new equipment systematically to OEM specifications	mise en service	démarrage initial d'un nouvel appareil de façon absolument conforme aux spécifications du fabricant d'équipement d'origine
dip switches	a group of miniature switches	interrupteurs DIP	ensemble d'interrupteurs miniatures

extra-low- voltage	any voltage up to and including 30 V AC or 42.4 V DC as per CEC	très basse tension	selon le CCE, tension qui ne dépasse pas 30 V CA ou 42,2 V CC.
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	mise à la terre	liaison permanente et ininterrompue à la terre de courant admissible suffisant pour acheminer tout courant de défaut susceptible de la parcourir, et d'impédance suffisamment faible pour limiter la hausse de tension par rapport à la terre, de façon que les dispositifs de protection du circuit fonctionnent librement.
high-voltage	any voltage exceeding 1 000 V AC or 1 060 V DC as per CEC	haute tension	selon le CCE, tension supérieure à 1 000 V CA ou 1 060 V CC.
low-voltage	any voltage exceeding 30 V AC but not exceeding 1 000 V AC or exceeding 42.4 V DC but not exceeding 1 060 V DC as per CEC	basse tension	selon le CCE, tension supérieure à 30 V CA sans excéder 1 000 V CA ou supérieure à 42,4 V CC sans excéder 1 060 V CC.
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, nonmetallic), electrical, metallic and nonmetallic (EMT and ENT) underfloor raceways, cellular floors, surface raceways, wireways, cable trays, busways, and auxiliary gutters	canalisation	tout canal conçu pour contenir des fils, des câbles ou des barres omnibus. À moins d'être qualifié autrement dans les articles du CCE, ce terme comprend les conduits (rigides et flexibles, métalliques et non métalliques), les tubes électriques métalliques et non métalliques, les canalisations de plancher, les planchers cellulaires, les moulures, les goulottes guide-fils, les chemins de câbles, les barres blindées et les caniveaux auxiliaires.
unit equipment	a piece of equipment with its own storage battery, charging means, transfer switch, lamps or output terminals, test switch and indicators	luminaire autonome	appareil muni d'un accumulateur, d'un chargeur, d'un commutateur de transfert, de lampes ou de bornes de sortie, d'un interrupteur de test et d'indicateurs.