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Red Seal Occupational Standard

Construction Electrician

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Canada

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Title: Construction Electrician

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Foreword

The Canadian Council of Directors of Apprenticeship (CCDA) recognizes this Red Seal Occupational Standard (RSOS) as the Red Seal standard for the Construction 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 Labour Market Integration Directorate

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Special thanks are offered to Matt Andrea, Nova Scotia, who provided expert advice in the initial review.

This standard was prepared by the Apprenticeship and Sectoral Initiatives Directorate of ESDC. The coordinating, facilitating and processing of this standard were undertaken by employees of the standards development team of the Trades and Apprenticeship Division and of Nova Scotia, the host jurisdiction for this trade.

Structure of the Occupational Standard

This standard contains the following sections:

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

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

Trends in the Construction 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 nine essential skills is applied in this trade

Industry Expected Performance: description of the expectations regarding the level of performance of the tasks, 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 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

The first draft of the RSOS is drafted using technical content from a variety of existing industry-validated standards and curriculum, and in consultation with an expert in the trade. This draft standard organizes this content into the RSOS format. It categories all the tasks performed in the occupation and describes the skills and knowledge 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 CORE (NCC)	sub-task, task or MWA performed less than 70% of responding jurisdictions; these will not be tested by the Interprovincial Red Seal Examination for the trade
NATIONAL AVERAGE %	average percentage of questions assigned to each MWA and task in Interprovincial 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 Construction Electrician Trade

"Construction Electrician" is this trade's official Red Seal occupational title approved by the CCDA. This standard covers tasks performed by a construction electrician.

Construction electricians plan, design, assemble, install, alter, repair, inspect, verify, commission, connect, operate, maintain and decommission electrical systems. Electrical systems provide heating, lighting, power, alarm, security, communication and control in residential, agricultural, commercial, institutional, industrial, transportation and entertainment environments. Construction electricians may also perform the installation and maintenance of building automation systems. Construction electricians may be self-employed or employed by electrical contractors, utilities, and operations and maintenance departments of various facilities and municipalities.

Construction electricians must read and interpret electrical, mechanical, civil and architectural drawings and specifications such as electrical, building, fire, and jurisdictional codes to complete electrical installations. They use electrical test equipment and digital technology to ensure system safety, functionality and compatibility.

Construction electricians require good communication skills to negotiate, coordinate and facilitate work with clients, co-workers, jurisdictional authorities and other trades. Organizational skills are required to successfully plan and execute their work. They also require strong analytical and problem-solving skills in order to read and interpret diagrams, drawings and specifications. They require mechanical aptitude to install, diagnose and repair systems and components. It is beneficial for construction electricians to have good vision, the ability to distinguish colours, manual dexterity and a willingness to keep up with new developments in the trade. With changing technologies, digital and computer skills are necessary to this trade for job performance, learning methods and updating skills.

Their work may be performed indoors or outdoors, at heights, in confined spaces and in hazardous environments. They require stamina as construction electricians spend much of their time performing static and physical tasks such as climbing. Occupational risks include shocks, industrial diseases, arc flashes, falls and injury from repetitive motion, lifting and kneeling.

It is important to note that the work performed by construction electricians is not performed in isolation. This standard recognizes similarities or overlaps with the work of industrial electricians, powerline technicians, instrumentation and control technicians, and refrigeration and air conditioning mechanics. In addition, construction electricians work collaboratively with other trades such as plumbers, steamfitter/pipefitters, sprinkler fitters, industrial mechanic (millwright), sheet metal workers, bricklayers, carpenters and other skilled trades. Construction electricians also work with a wide variety of engineers and inspectors.

Construction electricians play a crucial role as mentors and trainers to apprentices in the trade. They may also advance to positions such as foremen, instructors, project managers, superintendents, estimators, technicians, system designers, electrical inspectors or start their own contracting business. Construction electricians may enhance their skills in different fields such as restorative, service or retrofit work rather than new construction.

Trends in the Construction Electrician Trade

Technology

There is an ongoing growth of new technologies that influence a number of areas of the industry. Some emerging technologies include solar power systems, wind power systems, smart buildings and smart grid.

There is a growth of renewable and alternative energy technologies such as solar photovoltaic, wind, hydrokinetic, geothermal, and tidal power systems in Canada which opens additional employment opportunities for qualified construction electricians. The emergence of electric vehicles (EV) in the Canadian market means there is an accompanying need for EV charging stations. Construction electricians would be responsible for installing and maintaining these EV charging stations. In some jurisdictions, construction electricians are responsible for the installation and maintenance of communication systems such as voice, data, audio, video and signalling. These systems are constantly evolving.

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). Construction electricians continue to work with modular wiring systems such as plug in luminaires, as well as traditional systems. A safer method of distributing power via Fault Managed Power (FMP) utilizing pulsed power or packet energy transfer is also surfacing. 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.

Construction electricians are starting to use three dimensional (3D) modelling and building information modelling (BIM) to facilitate construction methods such as interpreting and updating drawings. They are using mobile devices to receive specifications and other information and assist in diagnostic procedures.

Training and upgrading

The combination of new opportunities for construction electricians, new technologies and specialized skills has significantly impacted the electrical industry and triggered the development and delivery of related training. For example, upgrading and training could include areas such as fiber optics, structured cabling, wireless and local area networks (LAN), wireless Internet Protocol (IP) based lighting and building automation, and renewable energies. More than ever, construction electricians need to constantly upgrade and acquire new skills either through formal training, manufacturers' training or on-the-job training to stay current.

In some parts of the industry, more and more variable frequency drives (VFDs) are being installed. The VFDs along with other electronic components have the potential to create power quality problems. This requires electricians to become trained in the procedures for measuring electric power quality and the methods needed to monitor and improve the power quality.

Even though it is sometimes more cost effective to replace rather than repair electronic parts, a greater knowledge of electronic systems is still required to work with more complex electrical systems such as solid-state or computer-controlled.

Safety and environmental considerations

Safety standards continue to be emphasized and recognized in all aspects of the trade. Safety training is branching out to include areas such as arc flash, high-voltage, lock-out and tag-out, working at heights and supervision.

Incidents of serious injury and death of electrical workers underlines the dangerous nature of the work that electricians may be engaged in, and the shared responsibility that construction electricians have to implement safety training and follow safe work procedures. Electricians have to use their expertise on the worksite to assess risks, manage hazards and report issues as they arise.

The electrical industry in Canada embraces efficient and environmentally friendly construction techniques and energy saving devices such as light emitting diode (LED) lighting, automated lighting control, integrated control systems and variable speed drives. Additionally, Leadership in Energy and Environmental Design (LEED) is a growing trend for building construction. Many projects where construction electricians work are starting to migrate to a more sustainable environment. These include 'Net Zero' (carbon neutral) sites that are striving to reduce their carbon footprint. Carbon neutral includes lower carbon emission and 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 environmental initiative to recycle components such as ballasts and transformers.

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

Construction electricians read several types of documents such as purchase order agreements and instructions for installing systems and components. They also need to read and understand the Canadian Electrical Code (CEC), which contains legal and highly technical language. They also read other tradespersons' plans and specifications to understand the sequences of installation and locations of apparatus.

Document use

Construction electricians apply document use skills when they read, interpret and collate information from several documents such as plans, specifications, diagrams and schematics. They reference and interpret these documents when installing, assembling, diagnosing and repairing electrical components and systems. The translation of two-dimensional and three-dimensional drawings into three-dimensional applications also requires strong document use skills.

Writing

Writing skills are required for construction electricians to record information about their daily work, including hours worked, job locations and details of conversations about the job. They may also be required to record details on an incident or an accident report. They also make notations on as-built drawings to indicate changes from the original drawings, accurately describing the current installation. Labelling and identifying electrical systems also require this skill.

Oral communication

Strong oral communication skills are needed for construction electricians as they often need to relay messages, give directions, coordinate tasks with co-workers and discuss electrical code requirements with safety or building inspectors. They also regularly interact with supervisors, engineers, owners, architects, inspectors and other tradespersons to solve technical problems, to discuss work progress, and to ensure that work can meet scheduling and code requirements. They also exchange opinions with co-workers regarding critical safety issues related to complex installations.

Numeracy

Construction electricians use their numeracy skills to size and place electrical systems and components, ensuring that installations meet electrical code requirements. They take measurements and perform complex calculations using principles of mathematics such as geometry and trigonometry. Construction electricians also use numeracy skills to design or modify electrical installations.

Thinking skills

Construction electricians use thinking skills when they plan their work in order to ensure efficient use of time and resources. These skills also entail resolving issues such as system routing, and equipment placement and interconnection taking into account client specifications and code requirements. Additionally, these skills are called upon when consulting with other experienced tradespersons, manufacturers' representatives or engineers to solve technical problems.

Working with others

Construction electricians often work with co-workers, other trades, supervisors, owner representatives, architects, engineers, inspectors and suppliers. They may be required to demonstrate how to perform a task to other workers, mentor and orient or train new employees. They also participate in discussions about work processes or product improvement.

Digital technology

Construction electricians use different types of hand-held digital devices such as thermal imaging and multimeters to aid in diagnosing system and component failure. They also use different types of software to interface with these devices. They use their computer skills to improve the efficiency of product research, communication, record keeping, job tracking and information exchange with co-workers, other trades, supervisors, owner representatives, architects, engineers, inspectors and suppliers.

Continuous learning

It is important for construction electricians to stay up-to-date with changing requirements of the electrical code or with changes in technology, such as computer controls. They must be adaptable to change to advance their skills and increase their knowledge. These learning skills are applied when attending classes offered through unions, employers and other groups.

Industry Expected Performance

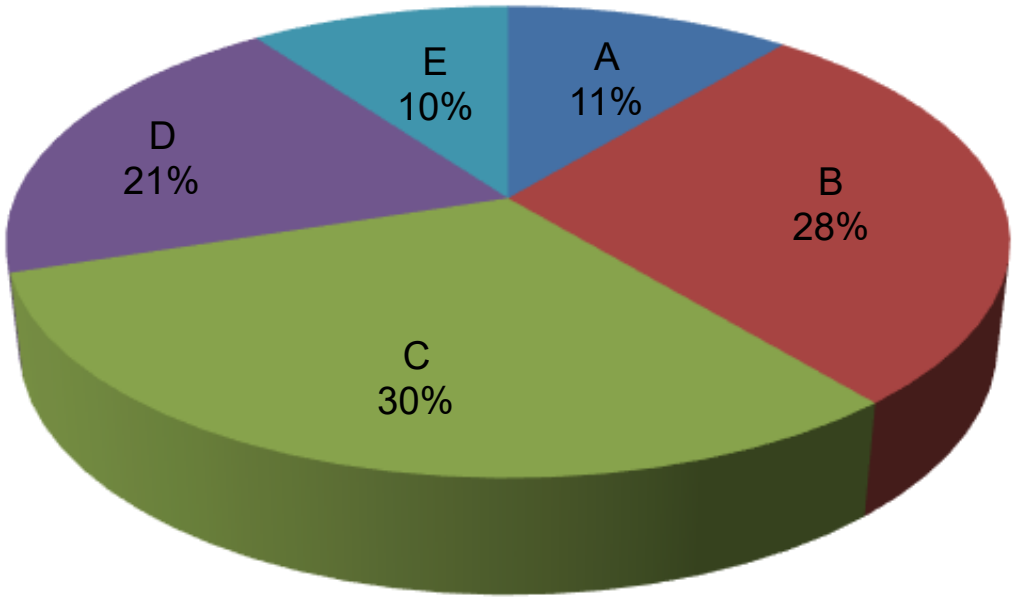
All tasks must be performed according to the applicable jurisdictional codes and standards. All health and safety standards must be respected and observed. Work should be done efficiently and to a high quality without material waste or environmental damage. All requirements of employers, engineers, designers, 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 languages of business as well as languages of instruction in apprenticeship programs.

Pie Chart

of Red Seal Examination Weightings



MWA A	Performs common occupational skills	11%
MWA B	Installs, services and maintains generating, distribution and service systems	28%
MWA C	Installs, services and maintains wiring systems	30%
MWA D	Installs, services and maintains motors and control systems	21%
MWA E	Installs, services and maintains signalling and communication systems	10%

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 (MWA) and the breakdown of questions assigned to the Tasks. The Interprovincial examination for this trade has 100 questions.

Construction Electrician
Task Matrix and Weightings

A – Performs common occupational skills — 11%

Task A-1 Performs safety-related functions 20%	A-1.01 Uses personal protective equipment (PPE) and safety equipment	A-1.02 Maintains safe work environment	A-1.03 Performs lock-out and tag-out procedures
Task A-2 Uses tools and equipment 19%	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 19%	A-3.01 Interprets plans, drawings and specifications	A-3.02 Organizes materials and supplies	A-3.03 Plans project tasks and procedures
	A-3.04 Prepares worksite	A-3.05 Finalizes required documentation	
Task A-4 Fabricates and installs support components 20%	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 16%	A-5.01. Performs startup and shutdown procedures	A-5.02 Performs commissioning and decommissioning of systems	
Task A-6 Uses communication and mentoring techniques 6%	A-6.01 Uses communication techniques	A-6.02 Uses mentoring techniques	

B – Installs, services and maintains generating, distribution and service systems

28%

Task B-7 **Installs, services and maintains consumer/supply services and metering equipment** **14%**	**B-7.01 Installs single-phase consumer/supply services and metering equipment**	**B-7.02 Installs three-phase consumer/supply services and metering equipment**	**B-7.03 Performs servicing and maintenance of single-phase consumer/supply services and metering equipment**
	B-7.04 Performs servicing and maintenance of three-phase consumer/supply services and metering equipment		
Task B-8 **Installs, services and maintains protection devices** **15%**	**B-8.01 Installs overcurrent protection devices**	**B-8.02 Installs ground fault, arc fault and surge protection devices**	**B-8.03 Performs servicing and maintenance of protection devices**
Task B-9 **Installs, services and maintains power distribution equipment** **15%**	**B-9.01 Installs power distribution equipment**	**B-9.02 Performs servicing and maintenance of power distribution equipment**	
Task B-10 **Installs, services and maintains power conditioning, uninterruptible power supply (UPS) and surge suppression systems** **8%**	**B-10.01 Installs power conditioning, UPS and surge suppression systems**	**B-10.02 Performs servicing and maintenance of power conditioning, UPS and surge suppression systems**	
Task B-11 **Installs, services and maintains bonding and grounding, and ground fault protection and detection systems** **13%**	**B-11.01 Installs bonding and grounding systems**	**B-11.02 Installs ground fault protection and detection systems**	**B-11.03 Installs lightning protection systems**
	B-11.04 Performs servicing and maintenance of bonding and grounding systems		

Task B-12 **Installs, services and maintains power generation and conversion systems** **8%**	**B-12.01 Installs alternating current (AC) generating systems**	**B-12.02 Performs servicing and maintenance of AC generating systems**	**B-12.03 Installs direct current (DC) generating and conversion systems**
	B-12.04 Performs servicing and maintenance of DC generating and conversion systems		
Task B-13 **Installs, services and maintains renewable energy generating and storage systems** **8%**	**B-13.01 Installs renewable energy generating and storage systems**	**B-13.02 Performs servicing and maintenance of renewable energy generating and storage systems**	
Task B-14 **Installs, services and maintains high-voltage systems** **7%**	**B-14.01 Installs high-voltage equipment**	**B-14.02 Installs high-voltage cables**	**B-14.03 Performs servicing and maintenance of high-voltage systems**
Task B-15 **Installs, services and maintains transformers** **12%**	**B-15.01 Installs extra-low-voltage transformers**	**B-15.02 Installs low-voltage single-phase transformers**	**B-15.03 Installs low-voltage three-phase transformers**
	B-15.04 Installs high-voltage transformers	**B-15.05 Performs servicing and maintenance of transformers**	

C – Installs, services and maintains wiring systems — 30%

Task C-16 Installs, services and maintains raceways, conductors, cables and enclosures 30%	C-16.01 Installs conductors and cables	C-16.02 Installs conduit and fittings	C-16.03 Installs raceways
	C-16.04 Installs boxes and enclosures	C-16.05 Performs servicing and maintenance of raceways, conductors, cables and enclosures	
Task C-17 Installs, services and maintains branch circuitry and devices 27%	C-17.01 Installs luminaires	C-17.02 Installs wiring devices	C-17.03 Installs lighting controls
	C-17.04 Installs lighting standards	C-17.05 Performs servicing of branch circuitry	C-17.06 Installs, services and maintains airport visual aid systems
	C-17.07 Installs, services and maintains traffic signal lights and controls		
Task C-18 Installs, services and maintains heating, ventilating and air-conditioning (HVAC) systems 14%	C-18.01 Connects HVAC systems and associated equipment	C-18.02 Installs HVAC controls	C-18.03 Performs servicing and maintenance of HVAC systems and controls
Task C-19 Installs, services and maintains electric heating systems 14%	C-19.01 Installs electric heating systems	C-19.02 Installs electric heating system controls	C-19.03 Performs servicing and maintenance of electric heating systems and controls
Task C-20 Installs, services and maintains exit and emergency lighting systems 11%	C-20.01 Installs exit and emergency lighting	C-20.02 Performs servicing and maintenance of exit and emergency lighting systems	
Task C-21 Installs, services and maintains cathodic protection systems 4%	C-21.01 Installs cathodic protection systems	C-21.02 Performs servicing and maintenance of cathodic protection systems	

D – Installs, services and maintains motors and control systems

21%

Task D-22 **Installs, services and maintains motor starters and controls** **38%**	**D-22.01 Installs motor starters**	**D-22.02 Performs servicing and maintenance of motor starters**	**D-22.03 Installs motor control devices**
	D-22.04 Performs servicing and maintenance of motor controls		
Task D-23 **Installs, services and maintains drives** **18%**	**D-23.01 Installs AC drives**	**D-23.02 Performs servicing and maintenance of AC drives**	**D-23.03 Installs DC drives**
	D-23.04 Performs servicing and maintenance of DC drives		
Task D-24 **Installs, services and maintains motors** **28%**	**D-24.01 Installs single-phase motors**	**D-24.02 Performs servicing and maintenance of single-phase motors**	**D-24.03 Installs three-phase motors**
	D-24.04 Performs servicing and maintenance of three-phase motors	**D-24.05 Installs DC motors**	**D-24.06 Performs servicing and maintenance of DC motors**
Task D-25 **Installs, programs, services and maintains automated control systems** **16%**	**D-25.01 Installs automated control systems**	**D-25.02 Performs servicing and maintenance of automated control systems**	**D-25.03 Programs and configures automated control systems**

E – Installs, services and maintains signalling and communication systems

10%

Task E-26 **Installs, services and maintains signalling systems** **44%**	**E-26.01 Installs fire alarm systems**	**E-26.02 Performs servicing and maintenance of fire alarm systems**	**E-26.03 Installs security and surveillance systems**
	E-26.04 Performs servicing and maintenance of security and surveillance systems		
Task E-27 **Installs, services and maintains communication systems** **26%**	**E-27.01 Installs voice/data/video (VDV) and community antenna television (CATV) systems**	**E-27.02 Installs public address (PA) and intercom systems**	**E-27.03 Installs nurse call systems**
	E-27.04 Performs servicing and maintenance of communication systems		
Task E-28 **Installs, services and maintains integrated control systems** **30%**	**E-28.01 Installs building automation systems**	**E-28.02 Installs building control systems**	**E-28.03 Performs servicing and maintenance of integrated 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 Construction 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
	Electrical Systems (Commissions and Decommissions)	Electrical Systems (Commissions and Decommissions)	Electrical Systems (Commissions and Decommissions)
	Protection Devices	Protection Devices	Protection Devices
	Support Components	Support Components	Support Components
		Raceways, Cables, Enclosures	Raceways, Cables, Enclosures
Safety-Related Functions 1.01 Uses personal protective equipment (PPE) and safety equipment 1.02 Maintains safe work environment. 1.03 Performs lock-out and tag-out procedures			

Level 1	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 Organizes materials and supplies 3.03 Plans project tasks and procedures 3.04 Prepares worksite 3.05 Finalizes required documentation			
Support Components 4.01 Fabricates support structures 4.02 Installs brackets, hangers and fasteners 4.03 Installs seismic restraint systems			
Electrical Systems (Commissions and Decommissions) 5.01 Performs startup and shutdown procedures 5.02 Performs commissioning and decommissioning of systems			
Communication Techniques 6.01 Uses communication techniques			**Mentoring Techniques** 6.02 Uses mentoring techniques

Level 1	Level 2	Level 3	Level 4
Consumer/Supply Services and Metering Equipment 7.01 Installs single-phase consumer/supply services and metering equipment 7.03 Performs servicing and maintenance of single-phase consumer/supply services and metering equipment		**Consumer/Supply Services and Metering Equipment** 7.02 Installs three-phase consumer/supply services and metering equipment 7.04 Performs servicing and maintenance of three-phase consumer/supply services and metering equipment	
Protection Devices 8.01 Installs overcurrent protection devices 8.02 Installs ground fault, arc fault and surge protection devices 8.03 Performs servicing and maintenance of protection devices			
Power Distribution Equipment 9.01 Installs power distribution equipment		**Power Distribution Equipment** 9.02 Performs servicing and maintenance of power distribution equipment	
			Power Conditioning, Uninterruptible Power Supply (UPS) and Surge Suppression Systems 10.01 Installs power conditioning, UPS and surge suppression systems 10.02 Performs servicing and maintenance of power conditioning, UPS and surge suppression systems
Bonding, Grounding and Ground-Fault Protection and Detection Systems 11.01 Installs grounding and bonding systems	**Bonding, Grounding and Ground-Fault Protection and Detection Systems** 11.01 Installs grounding and bonding systems 11.02 Installs ground-fault protection and detection systems 11.03 Installs lightning protection systems	**Bonding, Grounding and Ground-Fault Protection and Detection Systems** 11.01 Installs grounding and bonding systems 11.02 Installs ground-fault protection and detection systems 11.03 Installs lightning protection systems	**Bonding, Grounding and Ground-Fault Protection and Detection Systems** 11.04 Performs servicing and maintenance of bonding and grounding systems

Level 1	Level 2	Level 3	Level 4
	Power Generation and Conversion Systems 12.03 Installs direct current (DC) generating and conversion systems (NCC) 12.04 Performs servicing and maintenance of DC generating and conversion systems (NCC)	**Power Generation and Conversion Systems** 12.01 Installs alternating current (AC) generating systems 12.02 Performs servicing and maintenance of AC generating systems	
	Renewable Energy Generating and Storage Systems 13.01 Installs renewable energy generating and storage systems 13.02 Performs servicing and maintenance of renewable energy generating and storage systems		**Renewable Energy Generating and Storage Systems** 13.01 Installs renewable energy generating and storage systems 13.02 Performs servicing and maintenance of renewable energy generating and storage systems
			High-Voltage Systems 14.01 Installs high-voltage equipment 14.02 Installs high-voltage cables 14.03 Performs servicing and maintenance of high-voltage systems
	Transformers 15.01 Installs extra-low-voltage transformers 15.02 Installs low-voltage single-phase transformers	**Transformers** 15.03 Installs low-voltage three-phase transformers 15.04 Installs high voltage transformers 15.05 Performs servicing and maintenance of transformers	
Raceways, Conductors, Cables and Enclosures 16.01 Installs conductors and cables 16.02 Installs conduit and fittings 16.03 Installs raceways. 16.04 Installs boxes and enclosures 16.05 Performs servicing and maintenance of raceways, conductors, cables and enclosures	**Raceways, Conductors, Cables, Enclosures** 16.01 Installs conductors and cables 16.02 Installs conduit and fittings 16.03 Installs raceways 16.04 Installs boxes and enclosures 16.05 Performs servicing and maintenance of raceways, conductors, cables and enclosures		

Level 1	Level 2	Level 3	Level 4
Branch Circuitry and Devices 17.01 Installs luminaires 17.02 Installs wiring devices 17.03 Installs lighting controls 17.04 Installs lighting standards 17.05 Performs servicing of branch circuitry	**Branch Circuitry and Devices** 17.01 Installs luminaires 17.02 Installs wiring devices 17.03 Installs lighting controls 17.04 Installs lighting standards 17.05 Performs servicing of branch circuitry	**Branch Circuitry and Devices** 17.01 Installs luminaires 17.02 Installs wiring devices 17.03 Installs lighting controls 17.04 Installs lighting standards 17.05 Performs servicing of branch circuitry	**Branch Circuitry and Devices** 17.06 Installs, services and maintains airport visual aid systems 17.07 Installs, services and maintains traffic signal lights and controls
	HVAC Systems 18.01 Connects HVAC systems and associated equipment 18.02 Installs HVAC controls 18.03 Performs servicing and maintenance of HVAC systems and controls		
	Electric Heating Systems 19.01 Installs electric heating systems 19.02 Installs electric heating system controls 19.03 Performs servicing and maintenance of electric heating systems and controls		
	Exit and Emergency Lighting Systems 20.01 Installs exit and emergency lighting 20.02 Performs servicing and maintenance of exit and emergency lighting systems		
	Cathodic Protection Systems 21.01 Installs cathodic protection systems 21.02 Performs servicing and maintenance of cathodic protection systems		

Level 1	Level 2	Level 3	Level 4
	Motors and Controls 22.01 Installs motor starters 22.02 Performs servicing and maintenance of motor starters 22.03 Installs motor control devices 22.04 Performs servicing and maintenance of motor control devices	**Motors and Controls** 22.01 Installs motor starters 22.02 Performs servicing and maintenance of motor starters 22.03 Installs motor control devices 22.04 Performs servicing and maintenance of motor control devices	
		Drives 23.01 Installs AC drives 23.02 Performs servicing and maintenance of AC drives 23.03 Installs DC drives 23.04 Performs servicing and maintenance of DC drives	
	Motors 24.05 Installs DC motors 24.06 Performs servicing and maintenance of DC motors	**Motors** 24.01 Installs single-phase motors 24.02 Performs servicing and maintenance of single-phase motors 24.03 Installs three-phase motors 24.04 Performs servicing and maintenance of three-phase motors 24.05 Installs DC motors 24.06 Performs servicing and maintenance of DC motors	**Motors** 24.01 Installs single-phase motors 24.02 Performs servicing and maintenance of single-phase motors 24.03 Installs three-phase motors 24.04 Performs servicing and maintenance of three-phase motors 24.05 Installs DC motors 24.06 Performs servicing and maintenance of DC motors
			Automated Control Systems 25.01 Installs automated control systems 25.02 Performs servicing and maintenance of automated control systems 25.03 Programs and configures automated control systems

Level 1	Level 2	Level 3	Level 4
			Signalling Systems 26.01 Installs fire alarm systems 26.02 Performs servicing and maintenance of fire alarm systems 26.03 Installs security and surveillance systems 26.04 Performs servicing and maintenance of security and surveillance systems
Communication Systems 27.01 Installs voice/data/video (VDV) and community antenna television (CATV) systems 27.02 Installs public address (PA) and intercom systems. 27.03 Installs nurse call systems			**Communication Systems** 27.01 Installs voice/data/video (VDV) and community antenna television (CATV) systems 27.02 Installs public address (PA) and intercom systems 27.03 Installs nurse call systems 27.04 Performs servicing and maintenance of communication systems
			Integrated Control Systems 28.01 Installs building automation systems 28.02 Installs building control systems 28.03 Performs servicing and maintenance of integrated control systems

Major Work Activity A
Performs common occupational skills

Task A-1 Performs safety-related functions

Task descriptor
Construction electricians are responsible for ensuring the safety of themselves and others in the work environment. They must follow company, client and jurisdictional regulations.

It is critical that construction electricians be constantly aware of their surroundings and the hazards they may encounter.

A-1.01 Uses personal protective equipment (PPE) and safety equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-1.01.01P	identify ***site hazards*** and regulations requiring use of ***PPE*** and ***safety equipment***	***site hazards*** and regulations are determined according to site visits and by performing a pre-job analysis
A-1.01.02P	identify and apply ***safety regulations and standards***	***safety regulations and standards*** are followed according to company, client, site and AHJ requirements
A-1.01.03P	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
A-1.01.04P	select ***PPE*** and ***safety equipment***	***PPE*** and ***safety equipment*** are selected according to tasks, site hazards, OH&S, and company and site policies
A-1.01.05P	ensure fit of ***PPE***	***PPE*** are adjusted to ensure fit according to manufacturers' specifications
A-1.01.06P	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

Range of variables

PPE includes: shock hazard PPE, arc flash hazard PPE, head and eye protection, safety footwear, hand protection, hearing protection, respiratory protection

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

safety regulations and standards include: WHMIS, OH&S, CSA standards, client and company safety policy, general/prime contractor policies

site hazards include: working at heights, confined space, open excavation, live equipment, weather conditions, hazardous locations

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-1.01.01L	demonstrate knowledge of ***PPE*** and ***safety equipment***, and their ***applications*** and limitations	identify types of ***PPE*** and ***safety equipment***
		describe ***applications*** and limitations of ***PPE*** and ***safety equipment***
A-1.01.02L	demonstrate knowledge of regulatory requirements pertaining to ***PPE*** and ***safety equipment***	identify and interpret regulatory requirements and responsibilities
A-1.01.03L	demonstrate knowledge of procedures to use, maintain and store ***PPE*** and ***safety equipment***	describe procedures to use ***PPE*** and ***safety equipment***
		describe procedures to maintain and store ***PPE*** and ***safety equipment***

Range of variables

PPE includes: shock hazard PPE, arc flash hazard PPE, head and eye protection, safety footwear, hand protection, hearing protection, respiratory protection

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

applications include: hazardous locations, height, confined space

A-1.02 Maintain safe work environment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-1.02.01P	perform housekeeping practices	work area is clean and clutter-free
A-1.02.02P	identify, report and eliminate potential and existing ***hazards***	***hazards*** are identified, reported and mitigated according to OH&S, company and site policies, and visual inspection during site visit
A-1.02.03P	set up ***barriers and signage*** to identify ***hazards***	***hazards*** are well marked by ***barriers and signage***
A-1.02.04P	store materials and equipment	materials and equipment are stored in designated areas according to WHMIS, client and company policies and practices, site-specific practices and AHJ
A-1.02.05P	identify and respect limitations of self and others	work is performed according to limitations of self and others
A-1.02.06P	set up and identify locations containing ***safety components***	locations containing ***safety components*** are identified with signage and on job site map
A-1.02.07P	follow safe work practices	safe work practices are followed according to OH&S, and company and site policies
A-1.02.08P	identify ***designated substances*** to personnel	***designated substances*** are identified according to equipment labels and product documentation
A-1.02.09P	contain ***designated substances***	***designated substances*** are contained and disposed of according to jurisdictional regulations and company policy

Range of variables

hazards include: arc flashes/blasts, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation (including ultraviolet C), open holes, confined space, fire, tripping hazards, overhead work, working at heights

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

safety components include: first aid kits, fire extinguishers, material safety data sheets (MSDS), eye wash stations

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-1.02.01L	demonstrate knowledge of safe work practices	identify ***hazards*** and describe safe work practices to maintain safe work environment
A-1.02.02L	demonstrate knowledge of regulatory requirements pertaining to ***hazards*** and ***emergency situations***	identify and interpret regulatory requirements pertaining to ***hazards*** and ***emergency situations***
A-1.02.03L	demonstrate knowledge of containment methods for ***designated substances***	describe containment methods for ***designated substances***
A-1.02.04L	demonstrate knowledge of procedures used in ***emergency situations***	describe procedures used in ***emergency situations***

Range of variables

hazards include: arc flashes/blasts, liquid spills (flammable, corrosive, toxic), electric shocks, combustible dust, ionizing radiation (including ultraviolet C), open holes, confined space, fire, tripping hazards, overhead work, working at heights

emergency situations include: evacuation, fire, hazardous chemical alarms

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

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

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

	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 authorities and other trades including information of isolation of system or equipment
A-1.03.02P	identify circuit for lock-out and tag-out, and recognize other equipment that may present a hazard	circuit isolation point(s) and voltage are identified by referring to panel schedules, drawings, single-line diagrams, conductor, cable and equipment tags; other energy sources, and hazards are identified and secured
A-1.03.03P	select ***approved device*** to ensure lock-out and tag-out	***approved device*** is selected according to equipment
A-1.03.04P	identify power source, and de-energize and lock-out equipment	identified circuit is isolated, and equipment is de-energized and locked-out

A-1.03.05P	test system for zero potential using ***testing equipment***	system is tested for absence of voltage
A-1.03.06P	verify lock-out and tag-out	lock-out and tag-out is verified according to OH&S, and company and site policies

Range of variables

approved devices include: breaker lock, scissors, tag and arc flash protection equipment

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-1.03.01L	demonstrate knowledge of lock-out and tag-out procedures and legislation governing minimum standards	describe lock-out and tag-out procedures
		describe 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

Task A-2 Uses tools and equipment

Task descriptor

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

A-2.01 Uses common and specialty tools and equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-2.01.01P	organize and store ***tools, equipment*** and ***components***	***tools, equipment*** and ***components*** are organized and stored in designated cases and areas according to company and job site requirements
A-2.01.02P	clean, lubricate and adjust ***tools and equipment***	***tools and equipment*** are 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
A-2.01.04P	identify worn, damaged and defective ***tools and equipment***	worn, damaged and defective ***tools and equipment*** are tagged and replaced or repaired according to manufacturers' specifications
A-2.01.05P	change tool ***components***	tool ***components*** are changed according to job requirements
A-2.01.06P	identify hazards associated with ***tools and equipment***	hazards associated with ***tools and 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, powered tools and equipment, powder actuated tools, specialty tools and equipment, measuring instruments

components include: chucks, bits, blades, batteries (primary and rechargeable), cords, attachment plugs

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-2.01.01L	demonstrate knowledge of ***tools and equipment***, 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 ***tools and equipment***	describe procedures to inspect and maintain ***tools and equipment***
		describe procedures to operate ***tools and 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

Range of variables

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

A-2.02 Uses access equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-2.02.01P	identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified according to job site
A-2.02.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and ***potential hazards***
A-2.02.03P	select ***access equipment***	***access equipment*** is selected according to their 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, ***damages*** and defects

A-2.02.06P	report, tag and decommission worn, damaged and defective ***access equipment***	worn, damaged and defective ***access equipment*** 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 job site requirements
A-2.02.08P	work from approved and certified ***access 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
A-2.02.10P	perform ***standard maintenance***	***standard maintenance*** is performed according to manufacturers' specifications

Range of variables

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

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

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

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

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

Range of variables

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

regulatory requirements include: inspection documentation, training, certification

A-2.03 Uses rigging, hoisting and lifting equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-2.03.01P	identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified according to job site
A-2.03.02P	install barricades and signage to contain work zone	barricades and signage are installed according to regulations and ***potential hazards***
A-2.03.03P	select rigging, hoisting and lifting equipment	rigging, hoisting and lifting equipment is selected according to lifting limitation, 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 company 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 company procedures and manufacturers' specifications
A-2.03.10P	perform minor field maintenance	rigging, hoisting and lifting equipment is maintained according to manufacturers' specifications
A-2.03.11P	move load to final position	load is moved to final position according to drawings and specifications

Range of variables

potential hazards include: overhead hazards, dropped loads, damaged rigging hardware, congested worksites, confined spaces, open trenches

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-2.03.01L	demonstrate knowledge of hoisting, lifting and rigging equipment, their applications, limitations and procedures for use	identify types of rigging equipment and accessories, and describe their applications and procedures for use
		identify types of hoisting and lifting equipment and accessories, and describe their applications and procedures for use
		identify ***potential hazards***, and describe safe work practices pertaining to hoisting, lifting and rigging
		describe procedures to inspect, maintain and store hoisting, lifting and rigging equipment
A-2.03.02L	demonstrate knowledge of ***regulatory requirements*** pertaining to hoisting, lifting and rigging equipment	identify and interpret codes and regulations pertaining to hoisting, lifting and rigging equipment
A-2.03.03L	demonstrate knowledge of hoisting and lifting operations for electrical installations	identify types of knots, hitches, splices and bends, and describe their applications and procedures to tie them
		describe ***considerations*** 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, dropped loads, damaged rigging hardware, congested worksites, confined spaces, open trenches

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, electronic communications, audible/visual

Task A-3 Organizes work

Task descriptor

Construction electricians organize projects in order to safely and efficiently use material, labour, tools and equipment. They interpret drawings, plans and specifications to identify required resources. Prior to starting they must plan their tasks, prepare the worksite and organize the materials and supplies needed. Construction electricians must document their work and prepare as-built drawings and operations and maintenance (O&M) manuals.

A-3.01 Interprets plans, drawings and specifications

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-3.01.01P	identify symbols and **scaling**	symbols 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 obtaining measurements using ***scaling*** 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	visualize finished product based on information in plans, drawings and specifications	visualization is described to supervisor and verified according to job requirements
A-3.01.05P	determine if plans, ***drawings, schematics and specifications*** are current	plans, ***drawings, schematics and specifications*** are verified for existing installation

Range of variables

scaling includes: metric, imperial, custom

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-3.01.01L	demonstrate knowledge of ***drawings, schematics and specifications***, and their applications	identify types of ***drawings, schematics and specifications,*** and describe their applications
		identify documentation requirements for modifying drawings and specifications
		describe procedures to document changes made to equipment and wiring
A-3.01.02L	demonstrate knowledge of imperial and SI (système international) measurement systems	identify imperial and SI units of measurement used in trade documentation
A-3.01.03L	demonstrate knowledge of interpreting and extracting ***information*** from ***drawings, schematics and specifications***	interpret and extract ***information*** from ***drawings, schematics and specifications***
		explain how ***scaling*** is performed to position devices

Range of variables

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

information includes: elevations, scales, legends, symbols and abbreviations, notes and specifications, addendums, Construction Specifications Canada (CSC) Specification Divisions 25, 26, 27 and 28

scaling includes: metric, imperial, custom

A-3.02 Organizes materials and supplies

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-3.02.01P	identify and select ***materials*** and ***supplies***	***materials*** and ***supplies*** are selected according to drawings, specifications and CEC requirements
A-3.02.02P	locate, order and schedule delivery of ***materials*** and ***supplies***	***materials*** and ***supplies*** are located, ordered and delivered according to ***criteria***
A-3.02.03P	load, unload and store ***materials*** and ***supplies***	***materials*** and ***supplies*** are loaded, unloaded and stored according to ***factors***
A-3.02.04P	identify required ***materials*** and ***supplies***	***materials*** and ***supplies*** are identified by performing material take-off according to drawings and specifications

A-3.02.05P	coordinate receiving of ***materials*** and ***supplies***	***materials*** and ***supplies*** are received according to established schedule
A-3.02.06P	verify shipments for quality and quantity of ***materials*** and ***supplies***	***materials*** and ***supplies*** are counted and compared to order, and are inspected for shipping damage
A-3.02.07P	perform inventory control	inventory is counted, documented and stored in secured and environmentally protected area

Range of variables

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-3.02.01L	demonstrate knowledge of procedures to plan and organize ***materials*** and ***supplies***	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

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

sources of information include: drawings, specifications, client requirements

considerations include: available space, schedule, storage location

A-3.03 Plans project tasks and procedures

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-3.03.01P	determine job requirements	job requirements are determined according to site visit and approved **documentation**
A-3.03.02P	determine material, labour and equipment requirements	material, labour and equipment requirements are determined according to project and job specifications
A-3.03.03P	establish and maintain schedules	schedules are established and maintained according to ***criteria***
A-3.03.04P	coordinate work with other trades and end user	work is coordinated with other trades and end user according to ***requirements***
A-3.03.05P	draw and sketch layouts	layouts are drawn according to installation task at hand

Range of variables

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

criteria include: weather, product availability, project progression

requirements include: shutdown and installation sequencing

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-3.03.01L	demonstrate knowledge of procedures to plan and organize job tasks	identify ***sources of information*** relevant to planning job tasks and procedures
		describe ***considerations*** to plan and organize job tasks and procedures
		describe functions of project schedule charts

Range of variables

sources of information include: drawings, specifications, client requirements

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

A-3.04 Prepares worksite

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-3.04.01P	perform pre-job assessment	pre-job assessment is performed according to site visit
A-3.04.02P	identify traffic areas and ***potential hazards***	traffic areas and ***potential hazards*** are identified according to visual inspection during site visit
A-3.04.03P	identify ***hazardous locations***	***hazardous locations*** are identified according to division system of classification, area classification drawings and AHJ requirements
A-3.04.04P	identify wiring procedures in ***hazardous locations***	wiring procedures in ***hazardous locations*** are selected according to AHJ, CSA and CEC requirements
A-3.04.05P	identify equipment used in ***hazardous locations***	equipment used in ***hazardous locations*** is identified by reading equipment labels and product documentation
A-3.04.06P	identify locations for where sealing is required	seals are located according to AHJ, CSA and CEC requirements
A-3.04.07P	contain work zone	work zone is contained by installing barricades and signage according to job requirements and safety codes
A-3.04.08P	create openings and penetrations in structures and equipment	openings and penetrations are created according to job requirements and building codes
A-3.04.09P	ensure egress, lighting and ventilation in work area	egress is accessible with signage, work area is ventilated and level of lighting is according to safety and building codes
A-3.04.10P	ensure required materials and equipment are on site	materials and equipment are readily accessible for installation
A-3.04.11P	control workplace and storage access	workplace and storage access is controlled by gates, fences and barriers to limit access
A-3.04.12P	ensure surveys are completed and ***locates*** are marked-out	surveys are completed and ***locates*** are identified on the ground with paint and documented
A-3.04.13P	ensure hot work, building and safety permits are obtained	hot-work, building and safety permits are obtained

Range of variables

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

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

locates include: underground services and utilities, concealed building elements

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-3.04.01L	demonstrate knowledge of procedures to prepare worksite	identify ***sources of information*** to prepare worksite
		identify ***potential hazards*** to prepare worksite
		describe ***considerations*** to prepare worksite
A-3.04.02L	demonstrate knowledge of procedures to locate ***elements*** encased in concrete and soil	identify types of surveying equipment used to locate ***elements*** in concrete walls and floors, concrete slab on grade and in soil
		describe safety requirements when using x-ray surveying equipment in occupied buildings
A-3.04.03L	demonstrate knowledge of ***hazardous locations***	identify types of ***hazardous locations*** and describe safe work procedures
		identify types of potentially hazardous materials present and procedures to designate an area to be a ***hazardous location***
		identify equipment and fittings designed for installation and operation in ***hazardous locations***
		hazardous locations are identified according to division system of classification
A-3.04.04L	demonstrate knowledge of ***hazardous locations*** wiring methods	identify and describe wiring methods in ***hazardous locations***

Range of variables

sources of information include: drawings, specifications, AHJ, client requirements

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

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

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

A-3.05 Finalizes required documentation

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-3.05.01P	document alterations	alterations are documented by modifying plans, schematics and drawings to reflect changes and additions made to original application
A-3.05.02P	log data from various ***sources*** to assist with maintenance and replacement	paper and digital copies of setting files are saved to assist with maintenance and replacement
A-3.05.03P	compile maintenance manuals from installed equipment manufacturers' specifications	product data sheets for installed equipment are included in maintenance manuals
A-3.05.04P	submit final documentation, including as-built drawings to client	as-built drawings and O&M manuals are submitted to client according to job specifications

Range of variables

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-3.05.01L	demonstrate knowledge of documentation, its purpose, application and use	describe and identify types of documentation developed from different tasks
		describe procedures for finalizing documentation

Task A-4 Fabricates and installs support components

Task descriptor

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

A-4.01 Fabricates support structures

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

	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 are determined according to equipment size requirements, drawings, and manufacturers' specifications
A-4.01.03P	draw basic sketch	basic sketch is drawn with dimensions and measurements of support structure and equipment
A-4.01.04P	determine ***materials*** for support structure	***materials*** are selected according to job specifications and ***factors***
A-4.01.05P	select and use ***fasteners***	***fasteners*** are selected according to job specifications and site conditions
A-4.01.06P	prepare ***materials***	***materials*** are cut to length and shape, holes are drilled to size and location according to sketch, and painted and coated for corrosion protection
A-4.01.07P	assemble ***materials*** 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
fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

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

Range of variables

materials include: wood, steel, aluminum
fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints
tools and equipment include: measuring equipment, saws, drills, clamps, welding equipment

A-4.02 Installs brackets, hangers and fasteners

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-4.02.01P	select ***brackets***, ***hangers*** and ***fasteners***	***brackets***, ***hangers*** and ***fasteners*** are selected according to job and manufacturers' 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 ***brackets***, ***hangers*** and ***fasteners*** to structure	***brackets***, ***hangers*** and ***fasteners*** are secured following building lines according to job specifications and intended purposes

Range of variables

obstructions include: duct work, plumbing pipes, structural building elements, equipment
brackets include: channel, angle, T, L, floor, ceiling
hangers include: trapezes, pipe clamps, beam clamps
fasteners include: spring nuts, bolts, screws, concrete anchors

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-4.02.01L	demonstrate knowledge of ***brackets***, ***hangers*** and ***fasteners***, 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 ***brackets***, ***hangers*** and ***fasteners***	identify tools and equipment used to install ***brackets***, ***hangers*** and ***fasteners***, and describe their applications and procedures for use
		describe measurement and layout techniques to ensure ***brackets***, ***hangers*** and ***fasteners*** are positioned and mounted
		describe procedures for securing ***brackets***, ***hangers*** and ***fasteners*** to structure

Range of variables

brackets include: channel, angle, T, L, floor, ceiling
hangers include: trapezes, pipe clamps, beam clamps
fasteners include: spring nuts, bolts, screws, concrete anchors
building materials include: steel, concrete, brick, block, wood

A-4.03 Installs seismic restraint systems

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

	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, rods, galvanized cable, stainless steel cable , thimbles and clamps

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

	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, applications and requirements
		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 ***seismic restraint systems*** 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, rods, galvanized cable, stainless steel cable, thimbles and clamps

Task A-5 Commissions and decommissions electrical systems

Task descriptor

Construction electricians start up and commission electrical systems to ensure safe and intended operation. Commissioning of electrical systems may require liaison with equipment manufacturers. Construction electricians also shut down systems to perform preventative maintenance or to replace defective equipment. They decommission systems to prepare them for removal.

A-5.01 Performs startup and shutdown procedures

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-5.01.01P	identify equipment that needs to be energized	equipment to be energized is identified and its source of supply is verified according to documentation
A-5.01.02P	identify equipment that needs to be de-energized	equipment to be de-energized is identified and its source of supply is locked-out and tagged-out
A-5.01.03P	select tools and equipment	tools and equipment are selected according to task
A-5.01.04P	test cables and conductors	cables and conductors are tested for ground faults and phase identification with an insulation resistance tester and continuity tester
A-5.01.05P	verify drawings match field wiring	drawings match field drawings and wiring according to design
A-5.01.06P	verify **connected components** operate	***connected components*** operate in sequence according to function
A-5.01.07P	follow specifications sequence for startup	system is energized according to job specifications, type of system and manufacturers' specifications
A-5.01.08P	follow specifications sequence for shutdown	system is de-energized according to job specifications, type of system and manufacturers' specifications
A-5.01.09P	check ***system peripherals*** for specified operation	***system peripherals*** operate according to job and manufacturers' specifications
A-5.01.10P	install temporary protective ground equipment on shutdown and remove on startup	temporary protective ground equipment is installed and removed according to safety codes, and CEC and job requirements
A-5.01.11P	verify connections and terminations and torquing of bolts	connections are made and bolts torqued according to manufacturers' specifications

A-5.01.12P	inspect and remove shipping materials, tools, jumpers, debris, gravity pins, blocking and latching devices	inspection and removal of shipping materials, tools, jumpers, debris, gravity pins, blocking and latching devices are performed according to commissioning documentation, CSA standards, and company policies and procedures
A-5.01.13P	notify required personnel of startup and shutdown procedures	personnel is notified and cleared from area prior to startup and shutdown procedures

Range of variables

system peripherals include: detection system, status system, alarm systems

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-5.01.01L	demonstrate knowledge of purpose of startup and shutdown procedures	identify ***hazards***, and describe safe work practices pertaining to starting up and shutting down systems or equipment
		describe purpose of starting up and shutting down, and types of systems and equipment requiring it
		identify and interpret ***information sources*** and documentation pertaining to starting up and shutting down of systems or equipment
A-5.01.02L	demonstrate knowledge of procedures to start up and shut down systems or equipment	identify tools and equipment used to start up and shut down systems or equipment, and describe their applications and procedures for use
		describe startup and shutdown procedures for various types of systems and equipment

Range of variables

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

information sources include: O&M manuals, single-line diagrams, schematics, panel schedules, CEC, CSA standards, manufacturer specifications, job/contract specifications, site policies and procedures

A-5.02 Performs commissioning and decommissioning of systems

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-5.02.01P	select tools and equipment	tools and equipment are selected according to task
A-5.02.02P	check documentation and nameplate data for operational parameters	operational parameters are set or adjusted according to manufacturers' and job specifications
A-5.02.03P	confirm ***system peripherals*** are functional	***system peripherals*** are operating according to their intended purpose
A-5.02.04P	perform ***operational checks***	results of ***operational checks*** are documented
A-5.02.05P	visually inspect system for ***problems***	***problems*** are identified and corrected according to visual inspection
A-5.02.06P	adjust components to achieve desired operation	components are adjusted so that equipment operates as an integrated system
A-5.02.07P	isolate **potential energy** from equipment	equipment is de-energized using lockout and tagout procedures
A-5.02.08P	identify and remove ***equipment feed*** from distribution source	***equipment feed*** is disconnected and removed from distribution source
A-5.02.09P	collaborate with other trades to ensure all services are disconnected	other trades are informed of disconnected services, all hazards are removed and equipment is placed in zero energy state
A-5.02.10P	confirm system is de-energized	system is checked to verify absence of ***potential energy***

Range of variables

system peripherals include: detection system, status system, alarm systems
operational checks include: current, winding temperature, phase rotation, voltage, protection settings
problems include: wrong direction of rotation, out of specification rotation speed, alarm tripping, equipment malfunction
***potential* energy** includes: electrical, mechanical
equipment feed include: cable, conduit, conductors

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-5.02.01L	demonstrate knowledge of commissioning and decommissioning and their purpose	identify ***hazards*** and describe safe work practices pertaining to commissioning and decommissioning systems or equipment
		identify purpose of commissioning and decommissioning, and types of systems and equipment requiring them

		identify and interpret ***information sources*** and documentation pertaining to commissioning and decommissioning of systems or equipment
		identify ***diagnostic and test equipment*** for purpose of commissioning and decommissioning systems
A-5.02.02L	demonstrate knowledge of commissioning and decommissioning procedures	describe commissioning and decommissioning procedures

Range of variables

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

information sources include: O&M manuals, single-line diagrams, schematics, panel schedules, CEC, CSA standards, manufacturer specifications, job/contract specifications, site policies and procedures

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

Task A-6 Uses communication and mentoring techniques

Task descriptor

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

A-6.01 Uses communication techniques

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
A-6.01.01P	demonstrate 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 ***learning styles***
		describe effective listening and speaking skills
		identify ***personal responsibilities and attitudes*** that contribute to on-the-job success
		identify communication that constitutes ***harassment*** and ***discrimination***

Range of variables

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

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

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

personal responsibilities and attitudes include, but are not limited to: 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

A-6.02 Uses mentoring techniques

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

	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 skill to apprentice or learner	***steps required to demonstrate skill*** are performed
A-6.02.04P	set up conditions required for apprentice or learner to practice 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 and productivity	performance of apprentice or learner 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-***harassment*** in workplace	workplace is ***harassment*** and ***discrimination***-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

Range of variables

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

practice conditions means: guided, limited independence, full independence

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
A-6.02.01L	demonstrate knowledge of strategies for learning skills in workplace	describe importance of individual experience
		describe shared responsibilities for workplace learning

		determine one's own learning preferences and explain how these relate to learning new skills
		describe importance of different types of skills in workplace
		describe importance of ***essential skills*** in workplace
		identify different ***learning styles***
		identify different ***learning needs*** 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

Range of variables

essential skills are: reading, writing, document use, oral communication, numeracy, thinking skills, 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 point of lesson, linking lesson, demonstrating skill, providing practice, giving feedback, assessing skills and progress

Major Work Activity B

Installs, services and maintains generating, distribution and service systems

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

Task descriptor

Service entrance equipment provides power for single-phase and three-phase electrical systems and equipment. Consumer services can provide normal, emergency and temporary power. This equipment allows for the safe utilization of electricity.

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

Construction electricians service single- 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. Construction electricians may also work with non-utility metering equipment such as energy management with sub-metering or non-billing. Construction electricians typically install metering equipment such as current transformers (CTs) and voltage transformers (VTs).

B-7.01 Installs single-phase consumer/supply services and metering equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-7.01.01P	determine ***services***, and size and type of ***service components*** and ***service conductors***	***services***, and size and type of ***service components*** and ***service conductors*** are selected according to calculated load, client and CEC requirements, and site-specific conditions
B-7.01.02P	determine layout and location of ***service components***	layout allows for ***service components*** to be mounted according to AHJ and CEC clearance and height requirements to provide access for branch circuit installation and components

B-7.01.03P	determine trench size and minimum cover requirements	trench size and cover allow for installation of direct burial conductors, cables and underground raceways, and are constructed according to AHJ and CEC requirements
B-7.01.04P	determine overhead clearance	overhead clearance conforms to AHJ and CEC requirements for usage of area and proximity to structures
B-7.01.05P	select tools and equipment	tools and equipment are selected according to task
B-7.01.06P	protect ***service components*** for single-phase service	***service components*** are protected for single-phase service from environmental and mechanical damage, and from public access
B-7.01.07P	mount and secure ***service components***	***service components*** are securely mounted using ***fasteners*** designed to attach to material of support structure
B-7.01.08P	install ***service conductors***	***service conductors*** are installed without damage to insulation, without stress to conductor and terminations, and neutral conductor is identified
B-7.01.09P	terminate ***service conductors***	insulation is removed, antioxidant is applied and ***service conductors*** are tightened and secured according to manufacturers' specifications and CEC
B-7.01.10P	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
B-7.01.11P	identify service information on panels and ***metering equipment***	branch circuits and main breaker are labelled on panel directory and ***metering equipment***
B-7.01.12P	bond non-current carrying metallic ***service components***	non-current carrying metallic ***service components*** are bonded using CEC-approved bonding methods
B-7.01.13P	ground neutral conductor	neutral conductor is grounded at point of service using ***grounding electrodes*** according to CEC-approved grounding methods and AHJ
B-7.01.14P	bond ***non-electrical metallic piping and structures***	***non-electrical metallic piping and structures*** are bonded according to AHJ and CEC requirements
B-7.01.15P	remove and dispose of unserviceable ***service components*** and ***service conductors***, and update documentation	unserviceable ***service components*** and ***service conductors*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated

Range of variables

services include: overhead, underground, temporary

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

service conductors include: wire, cables, conductors

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

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-7.01.01L	demonstrate knowledge of ***single-phase services***, ***service components***, and their characteristics and applications	interpret codes and regulations pertaining to ***single-phase services***
		interpret information pertaining to ***single-phase services*** found on drawings and specifications
		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 ***single-phase 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*** and ***service conductors***
		identify and describe procedures to connect ***service conductors***
		identify procedures to ground and bond ***single-phase services***
B-7.01.03L	demonstrate knowledge of load calculations for ***single-phase service***	describe procedures to calculate load
		calculate load for ***single-phase service***

B-7.01.04L	demonstrate knowledge of single-phase systems	describe theory of single-phase Edison three-wire system
		describe single-phase circuit fundamentals and interpret AHJ requirements

Range of variables

single-phase services include: temporary service, overhead, underground, single and multiple metering
service conductors include: wire, cables, conductors
service components include: supports, enclosures, raceways, conduit, meter sockets, panels, service mast, point of attachment
fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

B-7.02 Installs three-phase consumer/supply services and metering equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-7.02.01P	determine ***services***, and size and type of ***service components*** and ***service conductors***	***services***, size and type of ***service components*** and ***service conductors*** are selected according to calculated load, client and CEC requirements, and site-specific conditions
B-7.02.02P	determine layout and location of ***service components***	layout allows for ***service components*** to be mounted according to AHJ and CEC clearance and height requirements to provide access for branch circuit installation
B-7.02.03P	determine trench size and minimum cover requirements	trench size and cover allows for installation of direct burial conductors, cables and underground raceways, and are constructed according to AHJ and CEC requirements
B-7.02.04P	determine overhead clearance	overhead clearance conforms to AHJ and CEC requirements for usage of area and proximity to structures
B-7.02.05P	select tools and equipment	tools and equipment are selected according to task
B-7.02.06P	protect ***service components*** for three-phase service	***service components*** for three-phase service are protected from environmental and mechanical damage, and from public access

B-7.02.07P	mount and secure ***service components***	***service components*** are securely mounted using ***fasteners*** designed to attach to material of support structure
B-7.02.08P	install ***service conductors***	***service conductors*** are installed without damage to insulation, without stress to conductors, and terminations and neutral and three-phase conductors are colour-coded
B-7.02.09P	terminate ***service conductors***	insulation is removed, antioxidant is applied and ***service conductors*** are tightened and secured according to manufacturers' specifications and CEC
B-7.02.10P	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
B-7.02.11P	identify service information on ***metering equipment*** and main disconnect	service information is identified on ***metering equipment*** and main disconnect
B-7.02.12P	bond non-current carrying metallic ***service components***	non-current carrying metallic ***service components*** are bonded according to CEC approved bonding methods
B-7.02.13P	ground neutral conductor	neutral conductor is grounded at point of service using ***grounding electrodes*** according to CEC-approved grounding methods and AHJ-
B-7.02.14P	bond ***non-electrical metallic piping and structures***	***non-electrical metallic piping and structures*** are bonded according to AHJ and CEC requirements
B-7.02.15P	remove and dispose of unserviceable ***service components*** and ***service conductors*** when replacing, and update documentation	unserviceable ***service components*** and ***service conductors*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated

Range of variables

services include: overhead, underground, temporary

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

service conductors include: wire, cables, conductors

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

grounding electrodes include: rods, plates, clamps, copper conductor

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-7.02.01L	demonstrate knowledge of ***three-phase services***, their characteristics and applications	interpret codes and regulations pertaining to ***three-phase services***
		interpret information pertaining to ***three-phase services*** found on drawings and specifications
		identify types of ***three-phase services***, and describe their characteristics and applications
		identify ***service components, service conductors*** and ***fasteners***, and describe their purpose and applications
		identify considerations and requirements for selecting ***three-phase services, service components*** and ***service conductors***
		identify ground fault and ground detection type protection systems, and describe their characteristics and applications
B-7.02.02L	demonstrate knowledge of procedures to install ***three-phase services***, ***service components*** and ***service conductors***	identify tools and equipment used to install ***three-phase services***, ***service components*** and ***service conductors***, and describe their applications and procedures for use
		identify sources of information and documentation required for installation of ***three-phase services***
		identify and describe procedures to install ***three-phase services***, ***service components*** and ***service conductors***
		identify and describe procedures to connect ***service conductors***
		identify procedures used to ground and bond ***three-phase services***
B-7.02.03L	demonstrate knowledge of load calculations for ***three-phase services***	describe procedures to calculate load
		calculate load for ***three-phase services***

Range of variables

three-phase services include: temporary service, overhead, underground, single and multiple metering
service components include: supports, enclosures, raceways, conduit, meter sockets, panels, service mast, point of attachment
service conductors include: wire, cables, conductors
fasteners include: screws, straps, inserts, anchors, wedge clamps, seismic restraints

B-7.03 Performs servicing and maintenance of single-phase consumer/supply services and metering equipment

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-7.03.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-7.03.02P	select tools and equipment	tools and equipment are selected according to task
B-7.03.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-7.03.04P	determine course of action	course of action is determined according to type of malfunction identified
B-7.03.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-7.03.06P	select replacement components	equivalent replacement components (original equipment manufacturer [OEM] replacement when mandated) are selected
B-7.03.07P	install replacement components	replacement components are installed according to manufacturers' specifications
B-7.03.08P	determine maintenance requirements	maintenance requirements are identified according to failure
B-7.03.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
B-7.03.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-7.03.11P	conduct tests	tests are conducted according to established maintenance schedule using ***diagnostic and test equipment***, and results documented
B-7.03.12P	update maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed

Range of variables

information includes: inspection report, log books, manufacturers' manuals, standard operating procedures

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-7.03.01L	demonstrate knowledge of single-phase systems	describe theory of single-phase Edison three-wire system
		describe single-phase circuit fundamentals and interpret AHJ requirements
B-7.03.02L	demonstrate knowledge of procedures to service and maintain single-phase services and their components	identify tools and equipment used to service and maintain single-phase services and their components, and describe their applications and procedures for use
		describe procedures to service single-phase services and their components
		describe procedures used to maintain single-phase services and their components

B-7.04 Performs servicing and maintenance of three-phase consumer/supply services and metering equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-7.04.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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 ***field assessments*** and ***diagnostic and test equipment*** results
B-7.04.04P	determine course of action	course of action is determined according to malfunction identified
B-7.04.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-7.04.06P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-7.04.07P	install replacement components	replacement components are installed according to manufacturers' specifications

B-7.04.08P	determine maintenance requirements	maintenance requirements are identified according to failure
B-7.04.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
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 results documented
B-7.04.12P	update maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed

Range of variables

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

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

	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 service three-phase services and their components
		describe procedures to maintain three-phase services and their components

Task B-8 Installs, services and maintains protection devices

Task descriptor

Overcurrent protection devices provide protection against overloads 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 that originate outside from entering into the whole system.

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

Construction electricians service overcurrent, ground fault, arc fault and surge protection 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.

B-8.01 Installs overcurrent protection devices

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-8.01.01P	determine type and size of ***enclosures***	***enclosures*** type and size are determined according to load requirements, environment and type of equipment
B-8.01.02P	determine type and rating of ***overcurrent protection devices***	type and rating of ***overcurrent protection devices*** are determined according to CEC requirements, and manufacturers' and equipment specifications
B-8.01.03P	select tools and equipment	tools and equipment are selected according to task
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 according to manufacturers' specifications
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 ***documentation*** and labels	branch and feeder circuits are labelled on directories and ***documentation*** updated
B-8.01.08P	remove and dispose of unserviceable ***enclosures***, ***overcurrent protection devices*** and ***hardware***, and update documentation	all unserviceable ***enclosures***, ***overcurrent protection devices*** and ***hardware*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated

Range of variables

enclosures include: CSA/National Electrical Manufacturers' Association (NEMA) classification, hazardous locations (as defined by Markings of Section 18 of CEC)

overcurrent protection devices include: fuses, breakers, relay protection

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	interpret codes and regulations pertaining to ***overcurrent protection devices***
		interpret information pertaining to ***overcurrent protection devices*** found on drawings and specifications
		explain effects of short-circuit current and describe associated damage to circuit
		identify types of ***overcurrent protection devices***, and describe their characteristics, applications, purpose and operation
		identify considerations and requirements for selecting ***overcurrent protection devices***
		explain purpose of coordination studies
		explain value of updating ***required documentation***
B-8.01.02L	demonstrate knowledge of procedures to install ***overcurrent protection devices***	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

Range of variables

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

B-8.02 Installs ground fault, arc fault and surge protection devices

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-8.02.01P	determine branch circuit and feeder circuits protection requirements	branch circuit and feeder circuits protection is determined according to location, environment, application and CEC requirements, and engineering studies
B-8.02.02P	determine type of ***ground fault protection devices*** to use	***ground fault protection devices*** are determined according to load, location, use and CEC requirements, and engineering studies
B-8.02.03P	determine type of ***arc fault protection devices*** to use	***arc fault protection devices*** are determined according to location and CEC requirements
B-8.02.04P	determine type of ***surge protection devices*** to use	***surge protection devices*** are determined according to client requirements and engineering studies
B-8.02.05P	select tools and equipment	tools and equipment are selected according to task
B-8.02.06P	mount and secure protection devices	protection devices are mounted and secured using ***hardware*** designed for equipment
B-8.02.07P	terminate protection devices	conductors are tightened and secured, and insulation is removed according to manufacturers' specifications
B-8.02.08P	update ***documentation*** and labels	branch and feeder circuits are labelled on directories and ***documentation*** updated
B-8.02.09P	remove and dispose of unserviceable protection devices when replacing, and update documentation	unserviceable ***ground fault protection devices, arc fault protection devices*** and ***surge protection devices*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated

Range of variables

ground fault protection devices include: ground fault circuit interrupter (GFCI) receptacle, breaker

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

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

documentation includes: as-builts, schematics, panel schedules, log sheets, equipment specifications, shop drawings

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-8.02.01L	demonstrate knowledge of ***ground fault, arc fault*** and ***surge protection devices***, their characteristics, applications and operation	interpret codes and regulations pertaining to ***ground fault, arc fault*** and ***surge protection devices***
		interpret information pertaining to ***ground fault, arc fault*** and ***surge protection devices*** found on drawings and specifications
		explain purpose and operation of ***ground fault, arc fault*** and ***surge protection devices***
		identify types of ***ground fault, arc fault*** and ***surge protection devices***, and describe their characteristics, applications and operation
		identify considerations and requirements for selecting ***ground fault, arc fault*** and ***surge protection devices***
		explain value of updating ***documentation***
B-8.02.02L	demonstrate knowledge of procedures to install ***ground fault, arc fault*** and ***surge protection devices***	identify tools and equipment used to install ***ground fault, arc fault*** and ***surge protection devices***, and describe their applications and procedures for use
		describe procedures to install ***ground fault, arc fault*** and ***surge protection devices***

Range of variables

ground fault protection devices include: GFCI receptacle, breaker

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

surge protection devices include: MOV, zener diodes, thyristors

documentation includes: as-builts, schematics, panel schedules, log sheets, equipment specifications, shop drawings

B-8.03 Performs servicing and maintenance of ground fault, arc fault and surge protection devices

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-8.03.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-8.03.02P	select tools and equipment	tools and equipment are selected according to task
B-8.03.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-8.03.04P	determine course of action	course of action is determined according to malfunction
B-8.03.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-8.03.06P	install replacement components	replacement components are installed according to manufacturers' specifications
B-8.03.07P	determine maintenance requirements	maintenance requirements are determined according to failure
B-8.03.08P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
B-8.03.09P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-8.03.10P	conduct tests	tests are conducted according to established maintenance schedule using ***diagnostic and test equipment***, and results documented
B-8.03.11P	update maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed

Range of variables

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-8.03.01L	demonstrate knowledge of theory used to service and maintain protection devices	describe theory used to service protection devices
		describe theory used to maintain protection devices
B-8.03.02L	demonstrate knowledge of procedures to service and maintain protection devices	identify tools and equipment used to service and maintain protection devices, and describe their applications and procedures for use
		describe procedures to service and maintain protection devices

Task B-9 Installs, services and maintains power distribution equipment

Task descriptor

Distribution equipment distributes power using feeder circuits for electrical systems and equipment. This equipment allows for safe utilization of electricity.

For the purpose of this standard, installation includes both new installations and upgrading of systems by removing and replacing components, and high-voltage distribution equipment is covered in Task B-14.

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

B-9.01 Installs power distribution equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-9.01.01P	determine size and type of ***power distribution equipment***, and type of ***enclosure***	size and type of ***power distribution equipment***, and type of ***enclosure*** are according to CEC calculated load, client requirements and site-specific conditions
B-9.01.02P	determine layout and location of ***power distribution equipment***	layout allows for ***power distribution equipment*** to be installed according to CEC required working clearance, and at a location where components to be installed can be mounted square, level and plumb matching building lines
B-9.01.03P	select tools and equipment	tools and equipment are selected according to task
B-9.01.04P	install and secure ***power distribution equipment***	***power distribution equipment*** is securely mounted to structure using ***fasteners*** designed to attach to material of support structure
B-9.01.05P	install feeder conductors	feeder conductors are installed without damage to insulation, without stress to conductor and terminations, and neutral and phase conductors are colour-coded according to CEC requirements
B-9.01.06P	terminate feeder conductor	feeder conductor connections are tightened and secured, and insulation is removed according to manufacturers' specifications, and antioxidant is applied

B-9.01.07P	conduct tests of ***power distribution equipment*** and feeder conductors	***power distribution equipment*** and feeder conductors are connected and function according to application requirements
B-9.01.08P	identify information on ***power distribution equipment***	***power distribution equipment*** is labelled according to job and client requirements
B-9.01.09P	remove and dispose of existing ***power distribution equipment***	used ***power distribution equipment***, ***enclosures*** and feeder conductors are removed and disposed of according to local codes and waste disposal requirements
B-9.01.10P	update documentation	documentation is updated to reflect changes carried out

Range of variables

power distribution equipment includes: panels, sub-panels, power distribution centres (PDC), switchboards, breakers, fuses, disconnects, racking equipment, CTs, VTs, busbars, splitters, MCCs, transfer switches

enclosures include: CSA/NEMA type designation, hazardous locations (as defined by Markings of Section 18 of CEC)

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

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

	describe procedures to connect ***power distribution equipment***
	describe procedures for transporting and moving electrical equipment

Range of variables

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

enclosures include: CSA/NEMA type designation, hazardous locations (as defined by Markings of Section 18 of CEC)

considerations include: load, voltage ratings, required circuit capacity

B-9.02 Performs servicing and maintenance of power distribution equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-9.02.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-9.02.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-9.02.03P	determine course of action	course of action is determined according to type of malfunction identified
B-9.02.04P	select tools and equipment	tools and equipment are selected according to task
B-9.02.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-9.02.06P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-9.02.07P	install replacement components	replacement components are installed according to manufacturers' specifications
B-9.02.08P	determine maintenance requirements	maintenance requirements are identified and revised according to failure
B-9.02.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
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	update maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed

Range of variables

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

field assessments include: sensory inspections, technical inspections

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-9.02.01L	demonstrate knowledge of theory used to service and maintain ***power distribution equipment*** and their components	describe theory to service ***power distribution equipment*** and their components
		describe theory used to maintain ***power distribution equipment*** and their components
B-9.02.02L	demonstrate knowledge of procedures to service and maintain ***power distribution equipment*** and their components	identify tools and equipment used to service and maintain ***power distribution equipment*** and their components, and describe their applications and procedures for use
		describe procedures to service and maintain ***power distribution equipment*** and their components

Range of variables

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

Task B-10 Installs, services and maintains power conditioning, uninterruptible power supply (UPS) and surge suppression systems

Task descriptor

Power conditioning systems include capacitors, harmonic mitigating transformers and saturation transformers, and are used to provide a smooth sinusoidal alternating current (AC) waveform thereby delivering a voltage of a constant level and power factor characteristics that enable load equipment to function as designed.

For the purpose of this standard, installation includes both new installations and upgrading of systems by removing and replacing components. Also, surge suppression systems refer to embedded devices within the power conditioning or UPS system.

Construction electricians service power conditioning, UPS and surge suppression systems by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure these systems are in good operating condition.

B-10.01 Installs power conditioning, UPS and surge suppression systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-10.01.01P	select tools and equipment	tools and equipment are selected according to task
B-10.01.02P	analyze existing system to assess ***conditions*** that require power conditioning	existing system is analyzed, and voltage and power factor characteristics outside of utility requirements are identified
B-10.01.03P	identify type of power conditioning required	type of power conditioning is identified according to system requirements
B-10.01.04P	perform calculations to size power conditioning and UPS systems, and surge suppression ***components***	power conditioning and UPS systems, and surge suppression ***components*** are sized according to requirements of application
B-10.01.05P	install ***components***	***components*** are securely installed 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 drawings, specifications, job, equipment type 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, UPS and surge suppression after installation and record results	power conditioning, UPS and surge suppression is connected and functions according to application requirements, and results documented
B-10.01.09P	remove existing power conditioning and UPS components when replacing	existing power conditioning and UPS components are removed with minimal impact to environment
B-10.01.10P	update documentation	documentation is updated to reflect changes carried out

Range of variables

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-10.01.01L	demonstrate knowledge of power conditioning, UPS and surge suppression systems, their characteristics and applications	interpret codes and regulations pertaining to power conditioning, UPS and surge suppression 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 ***surge suppression equipment*** used in power distribution system conditioning, 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 and capacitors
B-10.01.02L	demonstrate knowledge of procedures to install power conditioning, UPS and surge suppression systems	identify tools and equipment used to install power conditioning, UPS and surge suppression systems, and describe their applications and procedures for use
		describe procedures to install power conditioning, UPS and surge suppression systems

Range of variables

power factor correction equipment includes: synchronous condensers (motors), capacitors, inverters (renewable energy)
equipment used to reduce harmonics includes: passive and active filters, transformers and capacitors
surge suppression equipment includes: capacitors, shunt coils and diodes
UPS equipment includes: online, offline, maintenance bypass and static bypass, battery systems

B-10.02 Performs servicing and maintenance of power conditioning, UPS and surge suppression systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-10.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-10.02.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-10.02.03P	select tools and equipment	tools and equipment are selected according to task
B-10.02.04P	identify and remove defective ***components***	defective ***components*** are removed without damage to system or other components
B-10.02.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-10.02.06P	select replacement ***components***	replacement ***components*** (OEM replacement when mandated) are selected
B-10.02.07P	install replacement ***components***	replacement ***components*** are installed according to manufacturers' specifications

B-10.02.08P	conduct tests of power conditioning, UPS and surge suppression systems after repair	power conditioning, UPS and surge suppression systems are tested after repair, connected and function according to application requirements
B-10.02.09P	***clean, lubricate and adjust*** components	power conditioning, UPS and surge suppression system components are ***cleaned, lubricated and adjusted*** to restore to optimal conditions
B-10.02.10P	record tests in maintenance schedule	operational problems identified in tests are documented in maintenance schedule data with detailed notations
B-10.02.11P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications
B-10.02.12P	update maintenance log	maintenance log is updated to reflect tasks performed

Range of variables

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

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-10.02.01L	demonstrate knowledge of power conditioning, UPS and surge suppression systems, and their characteristics and applications	interpret codes and regulations pertaining to power conditioning, UPS and surge suppression 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 ***surge suppression equipment*** used in power distribution system conditioning, and describe their characteristics, applications and operation
		identify types of ***UPS equipment*** used in power distribution system conditioning, and describe their characteristics, applications and operation
B-10.02.02L	demonstrate knowledge of procedures to service and maintain power conditioning, UPS and surge suppression systems	identify tools and equipment used to service and maintain power conditioning, UPS and surge suppression systems, and describe their applications and procedures for use
		describe procedures to service and maintain power conditioning, UPS and surge suppression systems
		identify hazards with UPS systems when working with batteries, multiple sources and capacitors

Range of variables

power factor correction equipment includes: synchronous condensers (motors), capacitors, inverters (renewable energy)
equipment used to reduce harmonics includes: passive and active filters, transformers and capacitors
surge suppression equipment includes: capacitors, shunt coils and diodes
UPS equipment includes: online, offline, maintenance bypass and static bypass, battery systems

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

Task descriptor

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

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

Construction electricians service bonding and grounding protection systems by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure these systems are in good operating condition.

B-11.01 Installs grounding and bonding systems

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

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

B-11.01.07P	terminate grounding conductor	grounding conductor is securely terminated at source of supply and ***grounding electrode*** according to CEC requirements
B-11.01.08P	perform ground resistance test	ground resistance test is performed using ***ground testing equipment*** and documented
B-11.01.09P	determine bonding method	bonding method is determined according to environment, current, voltage, mechanical protection, and conductor material and size
B-11.01.10P	install ***bonding components***	***bonding components*** are installed in a manner to ensure continuity between non-current carrying components or apparatus of electrical systems and other metallic components
B-11.01.11P	terminate and interconnect ***bonding system components***	***bonding system components*** are terminated and interconnected according to drawings, specifications, and job and CEC requirements
B-11.01.12P	terminate bonding conductor	bonding conductor is securely terminated at source of supply, and at field devices and equipment according to CEC requirements

Range of variables

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

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

ground testing equipment includes: ground loop impedance tester, insulation resistance tester

bonding components include: metallic raceways, cables, grounding bushings, copper or aluminum conductors, connectors, locknuts

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-11.01.01L	demonstrate knowledge of grounding and bonding systems and equipment, their characteristics and applications	interpret codes and regulations pertaining to grounding and bonding
		interpret information pertaining to grounding and bonding found on drawings and specifications
		identify ***grounding methods***
		identify ***bonding methods***
		identify grounding conductors, equipment and components, and describe their characteristics and applications

		identify bonding conductors, equipment and components, and describe their characteristics and applications
		identify considerations and requirements for selecting grounding conductors, methods, equipment and components
		identify considerations and requirements for selecting bonding conductors, methods, equipment and components
		explain purpose and differences between grounding and bonding, and identify situations where interconnection of bonding 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 used to calculate grounding conductor size
B-11.01.03L	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 used to calculate bonding conductor size

Range of variables

grounding methods are determined by level of voltage

bonding methods are based on ampacity of conductor, metallic conduits, tubing, raceways and cabletray

B-11.02 Installs ground fault protection and detection systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-11.02.01P	determine type of ***ground fault system*** required	type of ***ground fault system*** required is determined according to client and CEC requirements
B-11.02.02P	select tools and equipment	tools and equipment are selected according to task

B-11.02.03P	position and mount ***ground fault system components***	***ground fault system components*** are securely mounted using ***fasteners*** designed to attach to material of support structure
B-11.02.04P	terminate and interconnect ***ground fault system components***	***ground fault system components*** are terminated and interconnected according to drawings and specifications, and job and CEC requirements
B-11.02.05P	set parameters for ***ground fault systems***	parameters are set to trip or alarm according to type of ***ground fault system*** installed and coordination studies
B-11.02.06P	test operation of ***ground fault system***	***ground fault system*** is tested to ensure trips or alarms are operational

Range of variables

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-11.02.01L	demonstrate knowledge of ***ground fault systems*** and their operation	identify types of ***ground fault systems***, and describe their characteristics and applications
		explain purpose of ***ground fault systems***
		interpret codes and regulations pertaining to ***ground fault systems***
		interpret information pertaining to ***ground fault systems*** found on drawings and specifications
		identify considerations and requirements for selecting ***ground fault system components***
B-11.02.02L	demonstrate knowledge of procedures to install ***ground fault system***	identify tools and equipment used to install ***ground fault system***, and describe their applications and procedures for use
		describe procedures to install ***ground fault systems*** and ***ground fault system components***

Range of variables

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

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

B-11.03 Installs lightning protection systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-11.03.01P	determine type of ***lightning protection system*** required	type of ***lightning protection system*** required is determined according to type and use of structure, and AHJ and client requirements
B-11.03.02P	select and lay out ***lightning protection components***	layout allows for ***lightning protection components*** to be installed to direct lightning energy to ground
B-11.03.03P	select tools and equipment	tools and equipment are selected according to task
B-11.03.04P	position and mount ***lightning protection components***	***lightning protection components*** are securely mounted using ***fasteners*** designed to attach to material of support structure
B-11.03.05P	terminate and interconnect ***lightning protection components***	***lightning protection components*** are terminated and interconnected according to drawings, specifications, and job and CEC requirements
B-11.03.06P	remove and dispose of existing ***lightning protection components*** when replacing and update documentation	used ***lightning protection components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated

Range of variables

lightning protection systems include: lightning arrester protection, structure protection

lightning protection components include: lightning rod (air terminal), intercepting conductors, down conductors, ground electrodes (ground rods), supports, lightning arresters

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-11.03.01L	demonstrate knowledge of ***lightning protection systems***, their characteristics, applications and operation	explain purpose of ***lightning protection systems***
		identify ***lightning protection systems***, and describe their characteristics, applications, and operation
		interpret codes and regulations pertaining to ***lightning protection systems***
		interpret information pertaining to ***lightning protection systems*** found on drawings and specifications
		identify considerations and requirements for selecting type of ***lightning protection systems***
B-11.03.02L	demonstrate knowledge of procedures to install ***lightning protection system***	identify tools and equipment used to install ***lightning protection system***, and describe their applications and procedures for use
		identify and describe procedures to install ***lightning protection systems*** and ***lightning protection components***

Range of variables

lightning protection systems include: lightning arrester protection, structure protection

lightning protection components include: lightning rod (air terminal), intercepting conductors, down conductors, ground electrodes (ground rods), supports, lightning arresters

B-11.04 Performs servicing and maintenance of bonding and grounding systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-11.04.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-11.04.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-11.04.03P	determine course of action	course of action is determined according to type of malfunction identified

B-11.04.04P	select tools and equipment	tools and equipment are selected according to task
B-11.04.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-11.04.06P	select equivalent replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-11.04.07P	install equivalent replacement components	equivalent replacement components are installed according to manufacturers' specifications
B-11.04.08P	determine maintenance requirements	maintenance requirements are identified according to failure
B-11.04.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
B-11.04.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-11.04.11P	conduct tests	tests are conducted according to established maintenance schedule using ***diagnostic and test equipment***, and results are documented
B-11.04.12P	update maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed

Range of variables

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

field assessments include: sensory inspections, technical inspections

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-11.04.01L	demonstrate knowledge of procedures to service and maintain bonding and grounding systems, and their components	identify tools and equipment used to service and maintain bonding and grounding systems, and their components, and describe their applications and procedures for use
		describe procedures to service bonding and grounding systems, and associated protection systems, and their components
		describe procedures to maintain bonding and grounding systems, and associated protection systems, and their components

Task B-12 Installs, services and maintains power generation 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 building is isolated from the power grid. DC conversion systems can also be used to convert three-phase AC power to DC power without needing a prime mover, for example 380-volt DC power supplies used in data centres.

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

Construction electricians service power generating systems by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure these systems are in good operating condition.

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	yes	yes	yes	yes	yes	yes	NV	NV	NV

	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
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 systems*** and ***AC generating system components*** are determined according to established 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 to account for ventilation according to manufacturers' and job specifications, and AHJ 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 and CEC requirements
B-12.01.06P	ground and bond ***AC generating system*** and ***AC generating system components***	***AC generating systems*** and ***AC generating system components*** are grounded and bonded using conductor sized according to CEC requirements

B-12.01.07P	program ***AC generating system*** and controls for startup and shutdown sequences	***AC generating systems*** are programmed according to functionality and established parameters, and test results documented
B-12.01.08P	conduct tests of ***AC generating system*** and ***AC generating system components*** after installation, and document results	***AC generating system*** and ***AC generating system components*** are tested, adjusted to ensure required voltage and frequency, connected and function according to job specifications, AHJ and CEC requirements, and results documented
B-12.01.09P	disconnect existing ***AC generating system*** and ***AC generating system components***, ensure safety of remaining installation and update documentation	***AC generating system*** and ***AC generating system components*** are disconnected, and remaining installations are terminated according to CEC requirements, and documentation updated

Range of variables

AC generating systems include: single-phase, three-phase, portable, stationary, transfer methods (manual or automatic)

AC generating system components include: transfer switch, cables, conductors, overcurrent devices, overload devices, fuel storage, Automatic Voltage Regulator (AVR), isolators, batteries, battery chargers

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-12.01.01L	demonstrate knowledge of **AC generating systems** and ***AC generating system components***, their characteristics, applications and operation	identify types of ***AC generating systems***, 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 ***AC generating systems*** and ***AC generating system components***
		interpret information pertaining to ***AC generating systems*** found on drawings and specifications
		interpret codes, standards and regulations pertaining to ***AC generating systems***
B-12.01.02L	demonstrate knowledge of procedures to install and connect ***AC generating systems***	identify tools and equipment used to install and connect ***AC generating systems***, and describe their applications and procedures for use
		describe procedures to install ***AC generating systems*** and ***AC generating system components***

	describe procedures to connect ***AC generating systems*** and ***AC generating system components***
	describe procedures to control output voltage, phase sequencing and frequency of AC generators

Range of variables

AC generating systems include: single-phase, three-phase, portable, stationary, transfer methods (manual or automatic)

AC generating system components include: transfer switch, cables, conductors, overcurrent devices, overload devices, fuel storage, AVR, isolators, batteries, battery chargers

B-12.02 Performs servicing and maintenance of AC generating systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-12.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-12.02.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-12.02.03P	select tools and equipment	tools and equipment are selected according to task
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 components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-12.02.06P	select replacement ***AC generating system components***	equivalent replacement ***AC generating system components*** (OEM replacement when mandated) are selected
B-12.02.07P	install replacement ***AC generating system components***	replacement ***AC generating system components*** are installed according to manufacturers' specifications
B-12.02.08P	conduct tests of ***AC generating system*** after repair	***AC generating system*** is connected after repair according to manufacturers' specifications, CEC requirements, and direction of rotation is according to specifications

B-12.02.09P	perform ***service procedures*** to ***AC 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 servicing and maintenance tasks performed
B-12.02.11P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

AC generating systems include: single-phase, three-phase, portable, stationary, transfer methods (manual or automatic)

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, voltage testers, ammeters, oscilloscope, power quality analyzers, high pot tester, thermographic imaging devices, phase rotation meters, insulation resistance testers, ground loop tester

AC generating system components include: transfer switch, cables, conductors, overcurrent devices, overload devices, fuel storage, AVR, isolators, batteries, battery chargers

service procedures include: cleaning cooling fans, adjusting belt tensioners, cleaning switches

	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 ***AC generating systems***, and describe their characteristics, applications and operation
		identify ***AC generating system components***, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***AC generating systems***
		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 service and maintain ***AC generating systems*** *and* ***AC generating system components***	identify tools and equipment used to service and maintain ***AC generating systems*** *and* ***AC generating system components***, and describe their applications and procedures for use

	describe procedures to service ***AC generating systems*** and ***AC generating system components***
	describe procedures to maintain ***AC generating systems*** and ***AC generating system components***

Range of variables

AC generating systems include: single-phase, three-phase, portable, stationary, transfer methods (manual or automatic)

AC generating system components include: transfer switch, cables, conductors, overcurrent devices, overload devices, fuel storage, AVR, 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	yes	yes	yes	yes	yes	yes	NV	NV	NV

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-12.03.01P	determine power requirements	power requirements are determined by performing load calculations and tests on connected load
B-12.03.02P	determine type and capacity of ***DC generating and conversion system*** and ***DC generating and conversion system components*** to be installed	type and capacity of ***DC generating and conversion systems*** and ***DC generating and conversion system components*** are determined according to requirements
B-12.03.03P	select tools and equipment	tools and equipment are selected according to task
B-12.03.04P	position and mount ***DC generating and conversion system*** and ***DC generating and conversion system components***	***DC generating and conversion system*** and ***DC generating and conversion system components*** are positioned to account for ventilation according to manufacturers' and job specifications, and AHJ requirements
B-12.03.05P	terminate and interconnect ***DC generating and conversion system*** and ***DC 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 and CEC requirements
B-12.03.06P	ground and/or bond ***DC generating and conversion system*** and ***DC generating and conversion system components***	***DC generating and conversion system*** and ***DC generating and conversion system components*** are grounded and/or bonded using conductor type and size according to CEC requirements

B-12.03.07P	program ***DC generating and conversion system*** and controls for startup and shutdown 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 ***DC generating and conversion systems*** and ***DC generating and conversion system components*** after installation, and record results	***DC generating and conversion systems*** and ***DC generating and conversion system components*** are tested after installation, connected and adjusted to ensure voltage according to job, AHJ and CEC requirements, and results documented
B-12.03.09P	disconnect existing ***DC generating and conversion systems*** and ***DC generating and conversion system components***, ensure safety of remaining installation, and update documentation	***DC generating and conversion systems*** and ***DC generating and conversion system components*** are disconnected, and remaining installations are terminated according to CEC requirements, and documentation is updated

Range of variables

DC generating and conversion systems include: portable, stationary, transfer methods (manual or automatic)

DC generating and conversion system components include: transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, solid state rectifiers, transformers, silicone controlled rectifiers (SCRs), insulated gate bipolar transistors (IGBTs)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-12.03.01L	demonstrate knowledge of ***DC generating and conversion systems*** and ***DC generating and conversion system components***, their characteristics, applications and operation	identify ***DC generating and conversion systems***, and describe their characteristics, applications and operation
		identify types of ***DC generating and conversion system components,*** and describe their characteristics and applications
		identify ***DC generators***, and describe their characteristics, applications and operation
		identify considerations and requirements for selecting ***DC generating and conversion systems*** and ***DC generating and conversion system components***
		interpret information pertaining to ***DC generating and conversion systems*** found on drawings and specifications

		interpret codes, standards and regulations pertaining to ***DC generating and conversion systems***
B-12.03.02L	demonstrate knowledge of procedures to install and connect ***DC generating and conversion systems*** and ***DC generating and conversion system components***	identify tools and equipment used to install and connect ***DC generating and conversion systems*** and ***DC generating and conversion system components***, and describe their applications and procedures for use
		describe procedures to install ***DC generating and conversion systems*** and ***DC generating and conversion system components***
		describe procedures to connect ***DC generating and conversion systems*** and ***DC generating and conversion system components***
		describe procedures to control output voltage of ***DC generators***

Range of variables

DC generating and conversion systems include: portable, stationary, transfer methods (manual or automatic)

DC generating system and conversion components include: transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, solid state rectifiers, transformers, SCRs, IGBTs

DC generators include: series, shunt, compound, portable, stationary

B-12.04 Performs servicing and maintenance of DC generating and conversion systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-12.04.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-12.04.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-12.04.03P	select tools and equipment	tools and equipment are selected according to task

B-12.04.04P	identify and remove defective ***DC generating and conversion system components***	defective ***DC generating and conversion system components*** are removed without damage to system or other components
B-12.04.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-12.04.06P	select replacement ***DC generating and conversion system components***	equivalent replacement ***DC generating and conversion system components*** (OEM replacement when mandated) are selected
B-12.04.07P	install replacement ***DC generating and conversion system components***	replacement ***DC generating and conversion system components*** are installed according to manufacturers' specifications
B-12.04.08P	conduct tests of ***DC generating and conversion system*** after repair	***DC generating and conversion system*** is tested after repair, connected and functions for application, and direction of rotation is according to specifications
B-12.04.09P	perform ***service procedures*** to ***DC generating and conversion system components***	***DC generating and conversion system components*** are restored to optimal conditions
B-12.04.10P	record tests in maintenance log	maintenance log is updated to reflect servicing and tasks performed
B-12.04.11P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, voltage testers, ammeters, oscilloscopes, high pot testers, thermographic imaging devices, insulation resistance testers, ground loop testers

DC generating and conversion systems include: portable, stationary, transfer methods (manual or automatic)

DC generating and conversion system components include: transfer switch, brushes, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, solid state rectifiers, transformers, SCRs, IGBTs

service procedures include: cleaning cooling fans, adjusting belt tensioners, adjusting and setting brushes, cleaning switches

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

Range of variables

DC generating and conversion systems include: portable, stationary, transfer methods (manual or automatic)

DC generating and conversion system components include: transfer switch, prime mover, cables, conductors, overcurrent devices, overload devices, fuel storage, solid state rectifiers, transformers, SCRs, IGBTs

DC generators include: series, shunt, compound, portable, stationary

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

Task descriptor

Alternative and renewable energy generation systems can be used to supplement power when power from the utility is unavailable or the building is isolated from the power grid. These systems can also feed energy back to the power grid. For the purpose of this standard, alternative systems are considered non-utility systems. Renewable energy systems are systems such as solar, wind, hydro or tidal powered that use renewable sources of energy. Energy storage systems can also be used independently of renewable energy generating systems.

Construction electricians install service alternative and renewable energy systems by troubleshooting, diagnosing faults, and repairing them. They also perform maintenance to ensure alternative and renewable energy systems are in good operating condition.

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

B-13.01 Installs renewable energy generating and storage systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-13.01.01P	determine energy requirements for application	calculations are performed by performing load calculations and tests according to applicable energy requirements or production requirements
B-13.01.02P	determine capacity of ***renewable energy system and components***	size and capacity of ***renewable energy system and components*** are determined according to CEC requirements
B-13.01.03P	determine type of ***renewable energy system connection***	***renewable energy 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 ***energy storage system***	type of ***energy storage system*** is determined according to technology and site 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 ***renewable energy systems and components, control system components*** and ***storage system components***	***renewable energy systems and components***, ***control system components*** and ***storage system components*** are securely mounted using ***fasteners*** designed to attach to material of support structure
B-13.01.08P	terminate and interconnect ***renewable energy system and components*** and ***control system components***	***renewable energy system and components*** and ***control system components*** are terminated and interconnected according to drawings, specifications, and job and CEC requirements
B-13-01.09P	terminate and interconnect ***energy storage system*** and ***components***	***energy storage system*** and ***components*** are terminated and interconnected according to drawings and specifications, manufacturers' specifications, job and CEC requirements, and local supply authority
B-13-01.10P	conduct tests of ***renewable energy system and components*** after installation	***renewable energy system and components*** are tested after installation, functional and connected according to application requirements
B-13-01.11P	conduct tests of ***energy storage system and components***	***energy storage system and components*** are tested after installation, functional and connected according to application requirements and manufacturers' specifications
B-13-01.12P	document test results	test results are documented
B-13-01.13P	remove existing equipment when replacing and update documentation	equipment is removed with minimal impact to environment and drawings reflect operational changes
B-13-01.14P	determine grounding and bonding requirements for renewable energy systems	method and materials for system grounding and bonding are selected

Range of variables

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

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

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters with anti-islanding capability

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-13.01.01L	demonstrate knowledge of ***renewable energy generating systems and components,*** and ***control system components***, their characteristics, applications and operation	identify types of ***renewable energy generating systems and components***, and describe their characteristics, applications and operation
		identify ***control system components***, and describe their characteristics, applications and operation
		identify types of ***renewable energy generating connections***
		interpret codes and regulations pertaining to ***renewable energy generating systems and components***
		define terminology associated with ***renewable energy generating systems and components***
B-13.01.02L	demonstrate knowledge of ***energy storage systems*** and ***energy storage system components***, their characteristics, applications and operation	identify types of ***energy storage systems*** and ***energy storage system components***, and describe their characteristics, applications and operation
		identify types of ***energy storage systems*** and ***energy storage system component*** connections
		interpret codes and regulations pertaining to ***energy storage systems*** and ***energy storage system components***
		define terminology associated with ***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 components,*** and ***control system components***	identify tools and equipment used to install and connect ***renewable energy generating systems and components***, and ***control system components***, and describe their applications and procedures for use
		describe procedures to install ***renewable energy generating systems and components,*** and ***control system components***
		describe procedures to connect ***renewable energy generating systems and components,*** and ***control system components***

B-13.01.04L	demonstrate knowledge of procedures to install and connect ***energy storage systems*** and ***energy storage system components***	identify tools and equipment used to install and connect ***energy storage systems*** and ***energy storage system 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***

Range of variables

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

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

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters with anti-islanding capability

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

B-13.02 Performs servicing and maintenance of renewable energy generating and storage systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-13.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-13.02.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-13.02.03P	select tools and equipment	tools and equipment are selected according to task
B-13.02.04P	identify and remove defective ***control system components***	defective ***control system components*** are removed without damage to system or other components

B-13.02.05P	repair malfunctioning ***control system components*** and verify repair	***control system components*** are repaired and tested to ensure they are operational according to manufacturers' specifications
B-13.02.06P	select replacement ***control system components***	equivalent replacement ***control system components*** (OEM replacement when mandated) are selected
B-13.02.07P	install replacement ***control system components***	replacement ***control system components*** are installed according to manufacturers' specifications
B-13.02.08P	conduct tests of ***renewable energy generating systems and components*** after repair	***renewable energy generating system and components*** are tested after repair, connected and function according to job, AHJ and CEC requirements
B-13.02.09P	conduct tests on ***energy storage systems*** and ***energy storage system components***	***energy storage systems*** and ***energy storage system components*** are tested after repair or scheduled maintenance, connected and function according to commissioning documentation, and job, AHJ, CEC and company requirements
B-13.02.10P	***lubricate, clean and adjust*** components	components are ***lubricated, cleaned and adjusted*** to restore to optimal conditions
B-13.02.11P	record tests in maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed
B-13.02.12P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

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

field assessments include: sensory inspections, technical inspections

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

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

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters with anti-islanding capability

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-13.02.01L	demonstrate knowledge of ***renewable generating energy systems and components,*** and ***control system components***, their characteristics, applications and operation	identify types of ***renewable energy generating systems and components***, and describe their characteristics, applications and operation
		identify ***control system components***, and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to ***renewable energy generating systems***
		define terminology associated with ***renewable energy generating systems***
B-13.02.02L	demonstrate knowledge of ***energy storage systems*** and ***energy storage system components***, their characteristics, applications and operation	identify types of ***energy storage systems*** and ***energy storage system components***, and describe their characteristics, applications and operation
		identify types of ***energy storage systems*** and ***energy storage system component*** connections
		interpret codes and regulations pertaining to ***energy storage systems*** and ***energy storage system components***
		define terminology associated with ***energy storage systems*** and ***energy storage system components***
B-13.02.03L	demonstrate knowledge of procedures to service and maintain ***renewable energy generating systems and components***, and ***control system components***	identify tools and equipment used to service and maintain ***renewable energy generating systems and components***, and ***control system components***, and describe their applications and procedures for use
		describe procedures to service ***renewable energy generating systems and components***, and ***control system components***
		describe procedures to maintain ***renewable energy generating systems and components***, and ***control system components***
B-13.02.04L	demonstrate knowledge of procedures to service and maintain ***energy storage systems*** and ***energy storage system components***	identify tools and equipment used to service and maintain ***energy storage systems*** and ***energy storage system components***, and describe their applications and procedures for use

	describe procedures to service ***energy storage systems*** and ***energy storage system components***
	describe procedures to maintain ***energy storage systems*** and ***energy storage system components***

Range of variables

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

control system components include: transfer switches, sun-tracking systems, batteries, charge controller, load bank, inverters with anti-islanding capability

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

Task B-14 Installs, services and maintains high-voltage systems

Task descriptor

Construction electricians assemble, install, erect and connect equipment, conductors and cables for high-voltage applications (1 000 V AC or 1 060 V DC) such as switchyards, sub-stations, electrical vaults, solar photovoltaic systems, chillers, MCC's and station ground grids. 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, installation includes both new installations and upgrading of systems by removing and replacing components.

Construction electricians service high-voltage systems by troubleshooting, diagnosing faults, and repairing them. They also perform maintenance to ensure these systems are in good operating condition.

B-14.01 Installs high-voltage equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-14.01.01P	determine installation requirements for ***high-voltage equipment***	requirements for ***high-voltage equipment*** are determined according to location, AHJ and client requirements
B-14.01.02P	determine layout of ***high-voltage equipment***	layout allows for ***high-voltage equipment*** to be installed level, square and plumb, matching building lines with required access and egress
B-14.01.03P	select tools and equipment	tools and equipment are selected according to task
B-14.01.04P	assemble ***high-voltage equipment***	***high-voltage equipment*** is assembled according to job requirements and manufacturers' specifications
B-14.01.05P	terminate conductors and cables, and interconnect ***high-voltage equipment***	conductors and cables are terminated, and ***high-voltage equipment*** is interconnected using busbars, cablebus or cabling systems according to application
B-14.01.06P	bond ***non-current carrying metallic components***	***non-current carrying metallic components*** are bonded to ground
B-14.01.07P	install station ground grid	station ground grid is installed according to step and touch voltage requirements and CEC requirements
B-14.01.08P	perform ground resistance test	ground resistance test is performed using ***testing equipment*** and documented

B-14.01.09P	perform ***acceptance tests***	***acceptance tests*** are conducted according to ***testing standards***
B-14.01.10P	install labelling and signage on high-voltage equipment	high-voltage equipment is labelled, and signage is evident according to client, site and CEC requirements
B-14.01.11P	update ***documentation*** required by AHJ	***documentation*** required by AHJ is updated with changes to installation of ***high-voltage equipment***
B-14.01.12P	remove and dispose of unserviceable ***high-voltage equipment***, their components and ***non-current carrying metallic components***	unserviceable ***high-voltage equipment*** , their components and ***non-current carrying metallic components*** are disposed of according to jurisdictional and federal legislation, and waste disposal requirements

Range of variables

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

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

testing equipment includes: ground loop impedance tester, insulation resistance tester

acceptance tests include: polarization, station ground grid resistance, high pot, phasing, functionality, timing, current injection

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-14.01.01L	demonstrate knowledge of ***high-voltage equipment***, their components, characteristics, applications and operation	identify ***high-voltage equipment*** and components, and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to ***high-voltage equipment***
		interpret information pertaining to ***high-voltage equipment*** found on drawings and specifications
		identify grounding conductors, equipment and components, and describe their characteristics, applications and operation
		identify bonding conductors, equipment and components, and describe their characteristics, applications and operation
		explain purpose of grounding grids in relation to step and touch voltages
		explain function of ***high-voltage equipment***

B-14.01.02L	demonstrate knowledge of procedures to install ***high-voltage equipment***	identify tools and equipment used to install ***high-voltage equipment***, and describe their applications and procedures for use
		describe procedures to install ***high-voltage equipment***
		describe procedures to install ground grid
		identify sources of information and ***documentation*** required by AHJ for installation of ***high-voltage equipment***
B-14.01.03L	demonstrate knowledge of testing procedures	identify tools and equipment used for testing, and describe their applications and procedures for use
		identify and describe testing procedures
		describe procedures to perform ground resistance testing and ***acceptance testing*** of ***high-voltage equipment***

Range of variables

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

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

acceptance tests include: polarization, ground grid resistance, high pot, phasing, functionality, timing, current injection

B-14.02 Installs high-voltage cables

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-14.02.01P	verify size and type of ***high-voltage cable***	size and type of ***high-voltage cable*** are verified according to calculated load, client requirements, existing site conditions and CEC
B-14.02.02P	determine layout and location of ***high-voltage cable*** installation	layout allows for ***high-voltage cable*** to be installed with clearance and at a location where components can be mounted level, square and plumb
B-14.02.03P	determine trench size and minimum cover requirements	trench size and cover allows for installation of direct burial cables and underground raceways according to area

B-14.02.04P	install flagging and warning tape	flagging and warning tape are installed according to job and AHJ requirements
B-14.02.05P	determine overhead clearance	overhead clearance conforms to AHJ and CEC requirements for usage of area and proximity to structures
B-14.02.06P	select tools and equipment	tools and equipment are selected according to task
B-14.02.07P	mount and secure ***high-voltage cable components***	***high-voltage cable components*** are securely mounted to equipment using ***fasteners*** designed for attachment to cable supports of support structure
B-14.02.08P	install ***high-voltage cables***	***high-voltage cables*** are installed without damage to insulation, without stress to conductor and terminations, and neutral and three-phase conductors are colour-coded as specified
B-14.02.09P	install terminations on ***high-voltage cables***	potheads and stress relief terminations are installed according to manufacturers' instructions
B-14.02.10P	conduct high pot test of ***high-voltage cables***	***high-voltage cables*** are tested to manufacturers' recommendations
B-14.02.11P	identify cable information on each conductor	each conductor is labelled and colour-coded according to CEC and client requirements
B-14.02.12P	bond cable shield	cable shield is bonded
B-14.02.13P	remove and dispose of ***high-voltage cables*** and ***high-voltage cable components*** when replacing, and update documentation	used ***high-voltage cables*** and ***high-voltage cable components*** are removed and disposed of according to local codes and waste disposal requirements

Range of variables

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-14.02.01L	demonstrate knowledge of ***high-voltage cables***, their ***components***, characteristics, applications and operation	identify types of ***high-voltage cables***, and describe their characteristics, applications and operation
		identify ***high-voltage cable components***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***high-voltage cables*** and ***high-voltage cable components***

B-14.02.02L	demonstrate knowledge of procedures to install and terminate ***high-voltage cables*** and ***high-voltage cable components***	identify tools and equipment used to install and terminate ***high-voltage cables*** and ***high-voltage cable components***, and describe their applications and procedures for use
		describe procedures to install and terminate ***high-voltage cables*** and ***high-voltage cable components***
B-14.02.03L	demonstrate knowledge of testing procedures	identify tools and equipment used for testing, and describe their applications and procedures for use
		identify and describe testing procedures
		describe procedures to perform high pot tests

Range of variables

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

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

B-14.03 Performs servicing and maintenance of high-voltage systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-14.03.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-14.03.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-14.03.03P	determine course of action	course of action for type of malfunction is identified
B-14.03.04P	select tools and equipment	tools and equipment are selected according to task
B-14.03.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-14.03.06P	install replacement components	replacement components are installed according to manufacturers' specifications

B-14.03.07P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
B-14.03.08P	determine maintenance requirements	maintenance requirements are identified according to failure
B-14.03.09P	create maintenance schedule	maintenance schedule is created according to maintenance requirements
B-14.03.10P	follow maintenance schedule	maintenance tasks are done according to established schedule
B-14.03.11P	isolate components	components are isolated in order to allow for safe testing procedures
B-14.03.12P	conduct tests	tests are conducted according to established maintenance schedule using ***diagnostic and test equipment,*** and results documented
B-14.03.13P	update maintenance log and ***required documentation***	maintenance log and ***required documentation*** are updated to reflect servicing and maintenance tasks performed

Range of variables

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

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, voltage testers, ammeters, power quality analyzers, high pot testers, thermographic imaging devices, phase rotation meters, insulation resistance testers, ground loop impedance tester, arc flash protection equipment, ground straps

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-14.03.01L	demonstrate knowledge of ***high-voltage equipment***, their components, characteristics, applications and operation	identify ***high-voltage equipment*** and components, and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to ***high-voltage equipment***
		interpret information pertaining to ***high-voltage equipment*** found on drawings and specifications
		identify grounding conductors, equipment and components, and describe their characteristics, applications and operation
		identify bonding conductors, equipment and components, and describe their characteristics, applications and operation

		explain purpose of grounding grids in relation to step and touch voltages
		explain function of ***high-voltage equipment***
B-14.03.02L	demonstrate knowledge of procedures to service and maintain ***high-voltage equipment*** and their components	identify tools and equipment used to service and maintain ***high-voltage equipment*** and their components, and describe their applications and procedures for use
		describe procedures to service ***high-voltage equipment*** and their components
		describe procedures to maintain ***high-voltage equipment*** and their components
B-14.03.03L	demonstrate knowledge of procedures to service and maintain ***high-voltage cables***	identify tools and equipment used to service and maintain ***high-voltage cables***, and describe their applications and procedures for use
		describe procedures to service, ***high-voltage cables*** and ***high-voltage cable components***
		describe procedures to maintain ***high-voltage cables*** and ***high-voltage cable components***

Range of variables

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

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

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

Task B-15 Installs, services and maintains transformers

Task descriptor

Construction electricians install extra-low, low and high-voltage transformers to condition or alter voltage and current. Common uses of transformers include signal control, isolation, distribution and transmission.

Transformers are part of the distribution system, not the load.

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

Construction electricians service transformers by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure transformers are in good operating condition.

B-15.01 Installs extra-low-voltage transformers

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

	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 VA rating	type of ***extra-low-voltage transformer*** meets criteria for operation
B-15.01.03P	calculate conductor and cable requirements	conductor and cable 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 requirements
B-15.01.05P	install overcurrent devices	overcurrent devices are installed according to requirements such that transformer is protected
B-15.01.06P	position and mount ***extra-low-voltage transformer***	***extra-low-voltage transformer*** is positioned and mounted according to application
B-15.01.07P	connect transformer leads	transformer leads are connected according to application
B-15.01.08P	conduct tests of ***extra-low-voltage transformer*** after installation and record results	***extra-low-voltage transformer*** is tested after installation, connected and functions according to application requirements, and results recorded
B-15.01.09P	remove existing ***extra-low-voltage transformer*** when replacing and update documentation	***extra-low-voltage transformer*** is removed with minimal impact to environment and drawings are updated to reflect operational changes

Range of variables

extra-low voltage transformers include: Class 1 and Class 2 circuits according to the CEC

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

Range of variables

extra-low voltage transformers include: Class 1 and Class 2 circuits according to the CEC

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

B-15.02 Installs low-voltage single-phase transformers

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-15.02.01P	determine type of ***low-voltage single-phase transformer*** required and its kilovolt-amp (kVA) rating	type (including ventilation) of ***low-voltage single-phase transformer*** meets criteria for operation, manufacturers' specifications and AHJ
B-15.02.02P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements

B-15.02.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to CEC and ***system requirements***
B-15.02.04P	select tools and equipment	tools and equipment are selected according to task
B-15.02.05P	install overcurrent devices	overcurrent devices are installed according to ***system requirements*** such that transformer is protected
B-15.02.06P	position and mount ***low-voltage single-phase transformer***	***low-voltage single-phase transformer*** is positioned and mounted according to application, ventilation requirements, manufacturers' specifications and AHJ
B-15.02.07P	connect transformer leads	transformer leads are connected according to application
B-15.02.08P	select and change tap settings of ***low-voltage single-phase transformers***	tap settings of ***low- voltage single-phase transformers*** are selected and changed to ensure output voltage meets application requirements
B-15.02.09P	ground and bond transformer	transformer is grounded and bonded according to CEC requirements
B-15.02.10P	conduct ***tests*** of ***low-voltage single-phase transformer*** after installation and record results	***low-voltage single-phase transformer*** is tested after installation, connected and functions according to application, and results documented
B-15.02.11P	remove existing ***low-voltage single-phase transformer*** when replacing, and update documentation	***low-voltage single-phase transformer*** is removed with minimal impact to environment, and drawings updated to reflect operational changes

Range of variables

low-voltage single-phase transformers include: dry-type, dielectric liquid-filled
system requirements include: input/output voltage, polarities, kVA ratings, conductor size, overcurrent protection, disconnecting means
tests include: insulation test, voltage test, polarity test, turn ratio test

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-15.02.01L	demonstrate knowledge of ***low-voltage single-phase transformers*** and ***low-voltage single-phase transformer components***, their characteristics, applications and operation	identify ***low-voltage single-phase transformers***, and describe their characteristics, applications and operation
		identify ***low-voltage single-phase transformer components***, and describe their characteristics and applications
		interpret information found on ***low-voltage single-phase transformer*** nameplates

		explain transformer polarity and terminal markings
		describe considerations and requirements for selecting ***low-voltage single-phase transformers***
		interpret codes and regulations pertaining to ***low-voltage single-phase transformers***
B-15.02.02L	demonstrate knowledge of procedures to install ***low-voltage single-phase transformers*** and ***low-voltage single-phase transformer components***	identify tools and equipment used to install ***low-voltage single-phase transformers*** and ***low-voltage single-phase transformer components***, and describe their applications and procedures for use
		describe procedures to install ***low-voltage single-phase transformers*** and ***low-voltage single-phase transformer components***
		describe procedures to install ***low-voltage single-phase transformers*** in parallel

Range of variables

low-voltage single-phase transformers include: dry-type, dielectric liquid-filled

low-voltage single-phase transformer components include: oil pumps, ventilation fans, casing, core, primary and secondary windings, bushings, on-line and off-line tap changers, insulating oil/dielectric liquid

B-15.03 Installs low-voltage three-phase transformers

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-15.03.01P	determine type and kVA rating of ***low-voltage three- phase transformer*** required	type (including ventilation) and kVA rating of ***low-voltage three-phase transformer*** meets criteria for operation, manufacturers' specifications and AHJ
B-15.03.02P	calculate conductor and cable requirements	conductor and cable 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 CEC and ***system 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 such that transformer is protected according to ***system requirements***
B-15.03.06P	position and mount ***low-voltage three-phase transformer***	***low-voltage three-phase transformer*** is positioned and mounted according to application, ventilation requirements, manufacturers' specifications and AHJ and CEC requirements
B-15.03.07P	select and change tap settings of ***low-voltage three-phase transformer***	tap settings of ***low- voltage three-phase transformer*** are selected and changed such that output voltage meets application requirements
B-15.03.08P	connect transformer leads	transformer leads are connected according to application
B-15.03.09P	ground and bond transformer	transformer is grounded and bonded according to CEC requirements
B-15.03.10P	conduct ***tests*** of ***low-voltage three-phase transformer*** after installation and record results	***low-voltage three-phase transformer*** is tested after installation, connected and functions according to application
B-15.03.11P	remove existing ***low-voltage three-phase transformer*** when replacing and update documentation	existing ***low-voltage three-phase transformer*** is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

low-voltage three-phase transformers include: dry-type, dielectric liquid-filled

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-15.03.01L	demonstrate knowledge of ***low-voltage three-phase transformers low-voltage three-phase transformer***, their characteristics, applications and operation	identify types of ***low-voltage three-phase transformers***, and describe their characteristics, applications and operation
		identify ***winding configurations*** for ***low-voltage three-phase transformers***
		identify ***low-voltage three-phase transformer components***, and describe their characteristics and applications
		interpret information contained on ***low-voltage three-phase transformer*** nameplates
		explain transformer polarity and terminal markings

		identify considerations and requirements for selecting ***low-voltage three-phase transformers***
		interpret codes and regulations pertaining to ***low-voltage three-phase transformers***
B-15.03.02L	demonstrate knowledge of procedures to install ***low-voltage three-phase transformers*** and ***low-voltage three-phase transformer components***	identify tools and equipment used to install ***low-voltage three-phase transformers*** and ***low-voltage three-phase transformer components***, and describe their applications and procedures for use
		describe procedures to install ***low-voltage three-phase transformers*** and ***low-voltage three-phase transformer components***
		describe procedures to install ***low-voltage three-phase transformers*** in parallel

Range of variables

low-voltage three-phase transformers include: dry-type, dielectric liquid-filled

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

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

B-15.04 Installs high-voltage transformers

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-15.04.01P	determine type and kVA rating of ***high-voltage transformer*** required	type and kVA rating of ***high-voltage transformer*** meets criteria for operation
B-15.04.02P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements
B-15.04.03P	determine overcurrent devices	type and rating of overcurrent devices are determined according to ***system requirements***
B-15.04.04P	select tools and equipment	tools and equipment are selected according to task

B-15.04.05P	install overcurrent devices	overcurrent devices are installed such that transformer is protected according to ***system requirements***
B-15.04.06P	position and mount ***high-voltage transformer***	***high-voltage transformer*** is positioned and mounted according to application
B-15.04.07P	select and change tap settings of ***high-voltage transformers***	tap settings of ***high-voltage transformers*** are selected and changed such that output voltage meets application requirements
B-15.04.08P	connect transformer leads	transformer leads are connected according to application
B-15.04.09P	ground and bond transformer	transformer is bonded and grounded according to CEC requirements
B-15.04.10P	conduct ***tests*** of ***high-voltage transformer*** after installation and record results	***high-voltage transformer*** is tested after installation, connected and functions according to application, and results documented
B-15.04.11P	remove existing ***high-voltage transformer*** when replacing and update documentation	existing ***high-voltage transformer*** is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

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

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

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-15.04.01L	demonstrate knowledge of ***high-voltage transformers*** and ***high-voltage transformer components***, their characteristics, applications and operation	identify types of ***high-voltage transformers***, and describe their characteristics, applications and operation
		identify ***winding configurations*** for ***high-voltage transformers***
		identify ***high-voltage transformer components***, and describe their characteristics and applications
		interpret information contained on ***high-voltage transformer*** nameplates
		explain transformer polarity and terminal markings
		identify considerations and requirements for selecting ***high-voltage transformers***
		interpret codes and regulations pertaining to ***high-voltage transformers***

B-15.04.02L	demonstrate knowledge of procedures to install ***high-voltage transformers*** and ***high-voltage transformer components***	identify tools and equipment used to install ***high-voltage transformers*** and ***high-voltage transformer components***, and describe their applications and procedures for use
		describe procedures to install ***high-voltage transformers*** and ***high-voltage transformer components***
		describe procedures to install ***high-voltage transformers*** in parallel

Range of variables

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

high-voltage transformer components include: oil pumps, ventilation fans, casing, core, primary and secondary windings, desiccant breather, buchholz relay, bushings, dielectric liquid, on-line/off-line manual and automatic tap changers, oil temperature/pressure/ level gauges, phase indicators

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

B-15.05 Performs servicing and maintenance of transformers

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
B-15.05.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
B-15.05.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
B-15.05.03P	select tools and equipment	tools and equipment are selected according to task
B-15.05.04P	identify and remove defective transformer components	defective transformer components are removed without damage to system or other components
B-15.05.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
B-15.05.06P	install replacement components	replacement components are installed according to manufacturers' specifications

B-15.05.07P	conduct tests of transformers after repair	transformer assembly is tested after repair, connected and functions according to job and CEC requirements, and manufacturers' specifications
B-15.05.08P	***clean and adjust*** transformer components	transformer components are ***cleaned and adjusted***, and transformer is restored to optimal conditions
B-15.05.09P	record tests in maintenance log	maintenance log is updated to reflect servicing and maintenance tasks performed
B-15.05.10P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, megohmmeters, dielectric oil testing equipment, voltage testers, thermographic imaging devices, power quality analyzers, turn ratio meters, arc flash protective equipment, temporary protective ground

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
B-15.05.01L	demonstrate knowledge of ***transformers*** and ***transformer components***, their characteristics, applications and operation	identify types of ***transformers***, and describe their characteristics, applications and operation
		identify ***transformer components*** and describe their characteristics and applications
		interpret codes and regulations pertaining to ***transformers***
		interpret information pertaining to ***transformers*** found on drawings and specifications
		describe construction of ***transformers***
		interpret information contained on ***transformer*** nameplates
B-15.05.02L	demonstrate knowledge of procedures to service and maintain ***transformers*** and ***transformer components***	identify tools and equipment used to service and maintain ***transformers*** and ***transformer components***, and describe their applications and procedures for use

	describe procedures to service ***transformers*** and ***transformer components***
	describe procedures to maintain ***transformers*** and ***transformer components***

Range of variables

transformers include: extra-low-voltage, dry-type, dielectric liquid-filled

transformer components include: oil pumps, ventilation fans, casing, core, primary and secondary windings, desiccant breather, buchholz relay, bushings, dielectric liquid, on-line/off-line manual and automatic tap changers, oil temperature/pressure/ level gauges, phase indicators

Major Work Activity C

Installs, services and maintains wiring systems

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

Task descriptor

Raceways support and protect conductors. Enclosures may be used to access and terminate the content of the raceway, and to facilitate the pulling and the interconnection of components. Raceways, conductors and cables are installed in various environments. Construction electricians install, service and maintain raceways, conductors and cables and restore the integrity of the firewall.

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

Construction electricians service raceways, conductors, cables and enclosures by performing visual inspections, troubleshooting, diagnosing faults, and repairing them. They also perform maintenance to ensure raceways, conductors, cables and enclosures are in good operating condition.

For the purpose of this standard, while cable trays are no longer defined as a raceway under the CEC, cable trays have been included with the raceway sub-task.

C-16.01 Installs conductors and cables

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-16.01.01P	determine ***installation requirements***, and select conductors, cables and ***conductor and cable components***	size, type and number of conductors, cables and ***conductor and cable components*** are selected, identified and colour-coded according to CEC requirements, AHJ, drawings and specifications
C-16.01.02P	select tools and equipment	tools and equipment are selected according to task

C-16.01.03P	mount, support and install conductors, cables, and ***conductor and cable components***	conductors, cables, and ***conductor and cable components*** are mounted, supported and installed according to drawings and specifications, CEC, National Building Code (NBC) and client requirements
C-16.01.04P	measure and cut conductors and cables	conductors and cables are measured and cut to allow for final routing and sufficient length for terminations according to CEC requirements
C-16.01.05P	prepare conductors and cables for termination	conductors and cables are cleaned and prepared for termination according to manufacturers' specifications
C-16.01.06P	terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings and specifications, manufacturers' specifications and AHJ
C-16.01.07P	complete documentation to reflect changes	all changes to new or updated installation are documented and made available to necessary parties
C-16.01.08P	determine requirements for removal of existing conductors, cables, connectors and supports	removal requirements of existing conductors, cables and ***conductor and cable components*** are determined according to client requirements and considering impact removal will have on facility
C-16.01.09P	remove conductors, cables, connectors and supports when replacing, and update documentation	conductors, cables, connectors and supports are removed according to electrical specifications and the National Fire Code (NFC), and remaining installations are supported and terminated according to CEC requirements

Range of variables

installation requirements include: purpose of cable or conductor, equipment required for installation, installation environment in locations such as hazardous (zones or divisions), wet, underground (direct buried or in raceway), outdoor, category 1, category 2, type of termination

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-16.01.01L	demonstrate knowledge of conductors, cables and ***conductor and cable components***, their characteristics, applications and operation	identify types of conductors, cables, and ***conductor and cable components***, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to conductors and cables

		interpret information pertaining to conductors and cables found on drawings and specifications
		identify considerations and requirements for removal of conductors, cables, and ***conductor and cable components***
		identify considerations and requirements for selecting conductors, cables, and ***conductor and cable components***
C-16.01.02L	demonstrate knowledge of procedures to remove or install conductors, cables, and ***conductor and cable components***	identify tools and equipment used to remove or install conductors, cables and ***conductor and cable components***, and describe their applications and procedures for use
		describe procedures to remove conductors, cables and ***conductor and cable components***
		describe procedures to ***prepare*** and install conductors, cables and ***conductor and cable components***
		describe procedures to terminate conductors and cables

Range of variables

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

preparation must include: preparation of aluminum conductors and cables

C-16.02 Installs conduit and fittings

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-16.02.01P	determine ***installation requirements*** and select conduit, tubing and fittings	size and type of conduit, tubing and fittings are selected according to drawings, specifications and CEC requirements
C-16.02.02P	select tools and equipment	tools and equipment are selected according to task
C-16.02.03P	determine routing of conduit and tubing	routing of conduit and tubing is practical for application and takes into consideration other trades

C-16.02.04P	measure, cut, thread and bend conduit	conduit are measured, cut, threaded and bent according to requirements of routing
C-16.02.05P	measure, cut and bend tubing	tubing is measured, cut and bent according to requirements of routing
C-16.02.06P	assemble, position, mount and support conduit, tubing and fittings	conduit, tubing and fittings are assembled, positioned, mounted and supported to meet requirements of application and without damage according to CEC and NBC requirements
C-16.02.07P	determine requirements for removal of existing conduit, tubing and fittings	removal requirements when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-16.02.08P	remove conduit, tubing and fittings when replacing, and update documentation	conduit, tubing and fittings are removed and remaining installations are supported and terminated according to CEC requirements

Range of variables

installation requirements include: purpose of conduit, tubing and fitting, equipment required for installation, installation environment in locations such as hazardous (zones or divisions), wet, underground (direct buried or in raceway), outdoor, category 1, category 2, type of termination

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-16.02.01L	demonstrate knowledge of conduit, tubing and fittings, their components, characteristics and applications	identify types of conduit, tubing and fittings, and describe their characteristics, applications and limitations
		identify conduit, tubing and fitting components, and describe their characteristics and applications
		identify tools and equipment related to conduit, tubing and fittings, and describe their applications and procedures for use
		interpret information pertaining to conduit, tubing and fittings found on drawings and specifications
		interpret codes and regulations pertaining to conduit, tubing and fittings
		identify considerations and requirements for removal of conduit, tubing and fittings, and their components
		identify considerations and requirements for selecting conduit, tubing and fittings, and their components

C-16.02.02L	demonstrate knowledge of procedures to remove or install conduit, tubing and fittings, and their components	identify tools and equipment used to remove or install conduit, tubing and fittings, and their components, and describe their applications and procedures for use
		describe procedures used for removal of conduit and tubing
		describe procedures to cut, thread (if applicable) and bend conduit and tubing
		describe procedures to install and support conduit and tubing systems
		describe procedures to select and install conduit and tubing related components

C-16.03 Installs raceways

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-16.03.01P	determine ***installation requirements*** and select raceways	size and type of ***raceway*** are selected according to drawings and specifications, and CEC requirements
C-16.03.02P	determine routing of ***raceway***	routing of ***raceway*** is practical for application and takes into consideration other trades
C-16.03.03P	select tools and equipment	tools and equipment are selected according to task
C-16.03.04P	measure, cut and form ***raceways***	***raceways*** are measured, cut and formed according to requirements of routing
C-16.03.05P	assemble, position, mount and support ***raceways***	***raceways*** are assembled, positioned, mounted and supported without damage according to application, CEC and NBC requirements
C-16.03.06P	determine requirements for removal of existing ***raceways***	removal requirements when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-16.03.07P	remove ***raceways*** and ***raceway components***, and update documentation	***raceways*** and ***raceway components*** are removed according to electrical specifications, and remaining installations are supported and terminated according to CEC requirements

Range of variables

installation requirements include: purpose of raceway, equipment required for installation, installation environment in locations such as hazardous (zones or divisions), wet, underground (direct buried or in raceway), outdoor, category 1, category 2, type of termination

raceways, in this sub-task include: cable tray, wireways, 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 16.02

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-16.03.01L	demonstrate knowledge of ***raceways*** and ***raceway components***, their characteristics and applications	identify types of ***raceways***, and describe their characteristics and applications
		identify ***raceway components***, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to ***raceways***
		interpret information pertaining to ***raceways*** found on drawings and specifications
		identify considerations and requirements for removal of ***raceways*** and their ***components***
		identify considerations and requirements for selecting ***raceways*** and their ***components***
C-16.03.02L	demonstrate knowledge of procedures to remove, install and support ***raceways*** and ***raceway components***	identify tools and equipment used to remove, install and support ***raceways*** and ***raceway components***, and describe their applications and procedures for use
		describe procedures to remove ***raceways*** and ***raceway components***
		describe procedures to install and support ***raceways*** and ***raceway components***

Range of variables

raceways, in this sub-task include: cable tray, wireways, 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 16.02

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

C-16.04 Installs boxes and enclosures

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-16.04.01P	determine ***installation requirements*** and select boxes and enclosures	size and type of boxes and enclosures are selected according to drawings and, specifications, environment and CEC requirements
C-16.04.02P	determine installation location for boxes and enclosures	location for box or enclosure is practical for application and takes into consideration other trades
C-16.04.03P	select tools and equipment	tools and equipment are selected according to task
C-16.04.04P	assemble, position, mount and support boxes and enclosures	boxes and enclosures are assembled, positioned, mounted and supported without damage according to application, CEC and NBC requirements
C-16.04.05P	determine requirements for removal of existing boxes and enclosures	removal requirements for existing boxes and enclosures when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-16.04.06P	remove boxes and enclosures when replacing	boxes and enclosures are removed and remaining installations are supported and terminated according to industry expected performance requirements
C-16.04.07P	update documentation	documentation is updated

Range of variables

installation requirements include: purpose of the box or enclosure, equipment required for installation, installation environment in locations such as hazardous (zones or divisions), wet, underground (direct buried or in raceway), outdoor, category 1, category 2, type of termination

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-16.04.01L	demonstrate knowledge of boxes and enclosures, and their characteristics and applications	identify types of boxes and enclosures, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to boxes and enclosures
		interpret information pertaining to boxes and enclosures found on drawings and specifications

		identify ***considerations*** and requirements for removal of boxes and enclosures
		identify ***considerations*** and requirements for selecting boxes and enclosures
C-16.04.02L	demonstrate knowledge of procedures to remove, install and support boxes and enclosures	identify tools and equipment used to remove, install and support boxes and enclosures, and describe their applications and procedures for use
		describe procedures to remove boxes and enclosures
		describe procedures to install and support boxes and enclosures

Range of variables

considerations include: volume, environment, accessibility, size of raceway or cable entering box or enclosure, CSA/NEMA classification

C-16.05 Performs servicing and maintenance of raceways, conductors, cables and enclosures

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-16.05.01P	select tools and equipment	tools and equipment are selected according to task
C-16.05.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results, and documented
C-16.05.03P	repair or replace malfunctioning component	malfunctioning component is repaired or replaced and system is returned to original state
C-16.05.04P	conducts tests of conductors and cables, and record results	conductors and cables are tested using ***diagnostic and test equipment*** and test results are documented
C-16.05.05P	re-terminate and test conductors for excessive heating	conductors are re-terminated according to manufacturers' specifications, and torquing and test results are documented
C-16.05.06P	update documentation	documentation is updated according to client and contractor requirements

Range of variables

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: megohmeters, multimeters, thermographic imaging devices, phase rotation meters, cable locators

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-16.05.01L	demonstrate knowledge of procedures to service raceways, cables and enclosures	identify tools and equipment used to service raceways, cables and enclosures, and describe their applications and procedures for use
		describe procedures to service raceways, cables and enclosures
		identify ***considerations*** when servicing raceways, cables and enclosures
C-16.05.02L	demonstrate knowledge of procedures to maintain raceways, cables and enclosures	identify tools and equipment used to maintain raceways, cables and enclosures, and describe their applications and procedures for use
		describe procedures to maintain raceways, cables and enclosures
		identify ***considerations*** when maintaining raceways, cables and enclosures

Range of variables

considerations include: changes from original installation, heat points, physical damage, information from end user

Task C-17 Installs, services and maintains branch circuitry and devices

Task descriptor

Various devices and luminaires are installed to meet the power and lighting requirements of the end user. Branch circuitry components are installed in a manner which makes the power safe and convenient to use. 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 and lighting controls control light functions, adjust lighting levels and save power. Construction electricians install and service branch circuitry.

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

Construction electricians service branch circuitry by performing visual inspections, troubleshooting, diagnosing faults and repairing them.

C-17.01 Installs luminaires

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.01.01P	determine type of ***luminaire*** and type of ***lamps*** required, and their ***installation requirements***	size and type of ***luminaire*** and ***lamps*** are selected according to application, drawings, specifications, and client and CEC requirements
C-17.01.02P	calculate branch circuit requirements	calculations are completed according to voltage and current requirements
C-17.01.03P	determine installation location for ***luminaire*** and ***lamps***	***luminaire*** and ***lamp*** locations are determined according to drawings, specifications, client requirements and design criteria for luminaire
C-17.01.04P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications and CEC requirements
C-17.01.05P	select tools and equipment	tools and equipment are selected according to task
C-17.01.06P	install branch circuit wiring	branch circuit wiring conductors are identified, selected and installed without damage to insulation and without stress to conductor and terminations according to drawings and specifications, and CEC requirements

C-17.01.07P	install and support ***luminaire***	***luminaire*** is installed and supported according to drawings and specifications, and client requirements
C-17.01.08P	terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings and specifications, and AHJ
C-17.01.09P	install ***lamps***	***lamps*** are installed according to drawings, specifications and manufacturers' specifications
C-17.01.10P	test for required operation	operation is verified by testing operation and lighting levels
C-17.01.11P	determine requirements for removal of ***luminaires***	removal requirements are determined according to client requirements and considering impact removal will have on facility
C-17.01.12P	remove existing ***luminaires*** and update documentation	***luminaires*** are removed when replacing and remaining installations are terminated according to industry expected performance requirements, and documents updated
C-17.01.13P	dispose of ***lamps*** and ballasts	***lamps*** and ballasts are disposed of according to local codes and waste disposal requirements

Range of variables

installation requirements include: purpose of luminaire, equipment required for installation, seismic requirements, installation environment in locations such as hazardous (zones or divisions), wet, outdoor, category 1, category 2, type of termination

luminaires include: poll mounted, wall mounted, ceiling mounted, pendant, surface, recessed

lamps include: high intensity discharge (HID), light emitting diode (LED), incandescent, fluorescent

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.01.01L	demonstrate knowledge of ***luminaires*** and ***lamps***, their characteristics, applications and operation	identify types of ***luminaires*** and ***lamps***, and describe their characteristics, applications and operation
		identify luminaire components and lamp components, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to ***luminaires*** and ***lamps***
		interpret information pertaining to ***luminaires*** and ***lamps*** found on drawings and specifications
		identify considerations and requirements for removal of ***luminaires***, ***lamps*** and their components

		identify considerations and requirements for selecting ***luminaires***, ***lamps*** and their components
C-17.01.02L	demonstrate knowledge of procedures to remove, install and support ***luminaires***, ***lamps*** and their components	identify tools and equipment used to remove, install and support ***luminaires*** and their components, and to install ***lamps*** and their components, and describe their applications and procedures for use
		describe procedures to remove ***luminaires***, ***lamps*** and their components
		describe procedures to install and support ***luminaires*** and their components, and install ***lamps*** and their components
		describe procedures to perform tests related to ***luminaires*** and ***lamps***
C-17.01.03L	demonstrate knowledge of procedures to troubleshoot ***luminaires*** and ***lamps***	identify tools and equipment used to troubleshoot ***luminaires*** and ***lamps***, and describe their applications and procedures for use
		describe procedures to troubleshoot ***luminaires*** and ***lamps***

Range of variables

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

C-17.02 Installs wiring devices

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.02.01P	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 client requirements
C-17.02.02P	determine installation location for ***wiring devices***	***wiring devices*** locations are determined according to manufacturers' specifications and client requirements
C-17.02.03P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications and CEC requirements

C-17.02.04P	select tools and equipment	tools and equipment are selected according to task
C-17.02.05P	install branch circuit wiring	branch circuit wiring conductors are identified, selected and installed without damage to insulation and without stress to conductors and terminations according to drawings, specifications, manufacturers' specifications and CEC requirements
C-17.02.06P	install ***wiring devices***	***wiring devices*** are installed according to drawings, specifications, manufacturers' specifications, and AHJ and CEC requirements
C-17.02.07P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, manufacturers' specifications and CEC requirements
C-17.02.08P	test for required operation	operation is verified by testing circuit for specified voltage and phasing
C-17.02.09P	select and install faceplate	faceplate is selected and installed according to industry and CEC requirements
C-17.02.10P	determine requirements for removal of wiring devices	removal requirements are determined according to company and client requirements and considering impact removal will have on site
C-17.02.11P	remove existing ***wiring devices*** when replacing and update documentation	existing ***wiring devices*** are removed when replacing and remaining installations are terminated according to industry requirements, and documentation updated

Range of variables

wiring devices include: indicator lamps, switches, timers, sensors, relays, controllers, disconnecting means, outlets, receptacles

installation requirements include: purpose of wiring device, equipment required for installation, installation environment in locations such as hazardous (zones or divisions), wet, underground (direct buried or in raceway), outdoor, category 1, category 2, type of termination

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.02.01L	demonstrate knowledge of ***wiring devices***, their characteristics, applications and operation	identify types of ***wiring devices,*** and describe their characteristics, applications and operation
		interpret codes, regulations and standards pertaining to ***wiring devices***
		interpret information pertaining to ***wiring devices*** found on drawings and specifications

		identify considerations and requirements for removal of ***wiring devices***
		identify considerations and requirements for selecting ***wiring devices***
C-17.02.02L	demonstrate knowledge of procedures to remove and install ***wiring devices***	identify tools and equipment used to remove and install ***wiring devices***, and describe their applications and procedures for use
		describe procedures to remove ***wiring devices***
		describe procedures to install ***wiring devices***

Range of variables

wiring devices include: indicator lamps, switches, timers, sensors, relays, controllers, disconnecting means, outlets, receptacles

C-17.03 Installs lighting controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.03.01P	determine ***control requirements*** and select ***lighting control components***	***control requirements*** are determined and ***lighting control components*** are selected according to required rating, required functionality for application, drawings and specifications
C-17.03.02P	determine circuitry and load requirements	calculations are completed according to voltage and current requirements
C-17.03.03P	select tools and equipment	tools and equipment are selected according to task
C-17.03.04P	assemble and install ***lighting control components***	***lighting control components*** are assembled and installed according to manufacturers' specifications and industry requirements
C-17.03.05P	label and terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings, specifications and manufacturers' specifications
C-17.03.06P	program and test lighting controls	program is verified by required operation of lighting controls according to specifications and client requirements, and test results are documented

C-17.03.07P	determine requirements for removal of existing lighting controls	removal requirements when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-17.03.08P	install and upgrade lighting controls	lighting controls are installed and upgraded according to performance specifications, client and AHJ (energy management) requirements

Range of variables

control requirements include: number and types of functions, loads controlled, number of circuits controlled, number of switching locations

lighting control components include: manual and automated, wireless, low-voltage switching, line voltage switching, extra-low-voltage switching and controls, time clocks, ambient light sensor, programmable controller, photo cells, occupancy/vacancy sensors, motion sensors, relays

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.03.01L	demonstrate knowledge of ***lighting control components***, their characteristics, applications and operation	identify types of ***lighting control components***, and describe their characteristics, applications and operation
		interpret information pertaining to ***lighting control components*** found on drawings and specifications
		interpret codes and regulations pertaining to ***lighting control components***
		identify considerations and requirements for removal of ***lighting control components***
		identify considerations and requirements for selecting ***lighting control components***
		identify requirements related to energy management
C-17.03.02L	demonstrate knowledge of procedures to remove or install, connect and test ***lighting control components***	identify tools and equipment used to remove or install, connect and test ***lighting control components***, and describe their applications and procedures for use
		describe procedures to remove ***lighting control components***
		describe procedures to install ***lighting control components***
		describe procedures to connect ***lighting control components***
		describe procedures to test ***lighting control components***

Range of variables

lighting control components include: manual and automated, wireless, low-voltage switching, line voltage switching, extra-low-voltage switching and controls, time clocks, ambient light sensor, programmable controller, photo cells and occupancy/vacancy sensors, motion sensors, relays

C-17.04 Installs lighting standards

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.04.01P	determine type of ***lighting standards*** required and associated installation requirements for application	size and type of ***lighting standards*** are selected for application according to drawings, specifications, manufacturers' specifications, and client and CEC requirements
C-17.04.02P	determine installation location for ***lighting standards***	***lighting standards*** locations are determined considering client requirements and design criteria for ***lighting standards***
C-17.04.03P	select tools and equipment	tools and equipment are selected according to task
C-17.04.04P	assemble, erect and secure ***lighting standards***	***lighting standards*** are assembled, erected and secured according to manufacturers' specifications
C-17.04.05P	determine requirements for removal of ***lighting standards***	removal requirements are determined according to client requirements and considering impact removal will have
C-17.04.06P	remove existing ***lighting standards*** when replacing and update documentation	***lighting standards*** are removed and remaining installations are terminated according to manufacturers' specifications

Range of variables

lighting standards include: roadway lighting, parking lot lighting and traffic control, driveway lighting, decorative aerial lighting, decorative area lighting, security lighting

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.04.01L	demonstrate knowledge of ***lighting standards*** and their applications	identify types of ***lighting standards*** and describe their applications
		identify lighting standard components, and describe their characteristics and applications

		interpret regulations pertaining to ***lighting standards***
		interpret information pertaining to ***lighting standards*** found on drawings and specifications
		identify considerations and requirements for removal of ***lighting standards*** and their components
		identify considerations and requirements for selecting ***lighting standards*** and their components
C-17.04.02L	demonstrate knowledge of procedures to remove and install ***lighting standards***	identify tools and equipment used to remove and install ***lighting standards***, and describe their applications and procedures for use
		describe procedures used for rigging and hoisting ***lighting standards*** for erection and dismantling
		describe procedures to remove ***lighting standards*** and their components
		describe procedures to assemble, erect and secure ***lighting standards***, and their components
C-17.04.03L	demonstrate knowledge of procedures to maintain and troubleshoot ***lighting standards***	identify tools and equipment used to maintain and troubleshoot ***lighting standards***, and describe their applications and procedures for use
		describe procedures to maintain ***lighting standards***
		describe procedures to troubleshoot ***lighting standards***

Range of variables

lighting standards include: roadway lighting, parking lot lighting and traffic control, driveway lighting, decorative aerial lighting, decorative area lighting, security lighting

C-17.05 Performs servicing of branch circuitry

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.05.01P	select tools and equipment	tools and equipment are selected according to task
C-17.05.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
C-17.05.03P	identify and remove defective components	defective components are removed without damage to system or other components
C-17.05.04P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
C-17.05.05P	install replacement components	replacement components are installed according to manufacturers' specifications
C-17.05.06P	conduct tests of ***branch circuitry*** after repair	***branch circuitry*** is tested after repair, connected and functions according to manufacturers' specifications

Range of variables

field assessments include: sensory inspections, technical inspections

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

branch circuitry, for the purpose of this sub-task, does not include airport runway lighting or traffic signals, which are covered in sub-tasks 17.06 and 17.07

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.05.01L	demonstrate knowledge of ***branch circuitry*** and their components, characteristics, applications and operation	identify types of ***branch circuitry*** and components, and describe their characteristics, applications and operation
C-17.05.02L	demonstrate knowledge of procedures to service ***branch circuitry*** and branch circuitry components	identify tools and equipment used to service ***branch circuitry*** and branch circuitry components, and describe their applications and procedures for use
		describe procedures to diagnose branch circuitry components
		describe procedures to repair/replace branch circuitry components

Range of variables

branch circuitry, for the purpose of this sub-task, does not include airport runway lighting or traffic signals, which are covered in sub-tasks 17.06 and 17.07

C-17.06 Installs, services and maintains airport visual aid systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.06.01P	determine ***installation requirements*** and select ***airport runway lighting system components*** and ***control components***	***airport runway lighting system components*** and ***control components*** are selected according to rating, required functionality for application, and according to drawings, specifications and CEC requirements
C-17.06.02P	select tools and equipment	tools and equipment are selected according to task
C-17.06.03P	determine circuitry and load requirements	calculations are completed according to voltage and current requirements
C-17.06.04P	assemble and install ***airport runway lighting system components***	***airport runway lighting system components*** are assembled and installed according to manufacturers' specifications
C-17.06.05P	label and terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings, specifications, manufacturers' specifications and AHJ
C-17.06.06P	test lighting and controls	tests verify specified operation of lighting and controls, and test results are documented
C-17.06.07P	service and maintain airport runway lighting systems and ***control components***	airport runway lighting systems and ***control components*** are maintained according to client requirements and manufacturers' specifications

C-17.06.08P	determine requirements for removal of existing airport runway lighting systems and ***airport runway lighting system components***	removal requirements when performing an upgrade are determined according to client requirements and considering impact removal will have
C-17.06.09P	remove existing airport runway lighting systems and ***airport runway lighting system components*** when replacing, and update documentation	airport runway lighting systems and ***airport runway lighting system components*** are removed, and remaining installations are terminated according to industry expected performance requirements, and documentation updated

Range of variables

installation requirements include: purpose of wiring device, equipment required for installation, installation environment in locations such as hazardous, wet, outdoor, category 1, category 2

airport runway lighting system components include: constant current regulator (CCR), lighting transformers, medium intensity runway lights, high intensity runway lights, pull pits, ground counter poise, contactless energy data and distribution technology

control components include: aircraft radio control of aerodrome lighting (ARCAL)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.06.01L	demonstrate knowledge of airport runway lighting systems and ***airport runway lighting system components***, their characteristics, applications and operation	identify types of airport runway lighting systems, and describe their characteristics, applications and operation
		identify ***airport runway lighting system components***, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to airport runway lighting systems
		interpret information pertaining to airport runway lighting systems found on drawings and specifications
		identify considerations and requirements for removal of airport runway lighting systems and ***airport runway lighting system components***
		identify considerations and requirements for selecting airport runway lighting systems and ***airport runway lighting system components***
C-17.06.02L	demonstrate knowledge of procedures to remove or install airport runway lighting systems and ***airport runway lighting system components***	identify tools and equipment used to remove or install airport runway lighting systems and ***airport runway lighting system components***, and describe their applications and procedures for use

	describe procedures to remove airport runway lighting systems and ***airport runway lighting system components***
	describe procedures to install airport runway lighting systems and ***airport runway lighting system components***
	describe procedures to perform tests related to airport runway lighting systems

Range of variables

airport runway lighting system components include: CCR, lighting transformers, medium intensity runway lights, high intensity runway lights, pull pits, ground counter poise, contactless energy data and distribution technology

C-17.07 Installs, services and maintains traffic signal lights and controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-17.07.01P	determine installation requirements and select traffic signal light system and ***control components***	traffic signal light systems and ***control components*** are selected according to required rating and functionality for application, drawings, specifications and CEC requirements
C-17.07.02P	select tools and equipment	tools and equipment are selected according to task
C-17.07.03P	determine circuitry and load requirements	calculations are completed according to voltage and current requirements
C-17.07.04P	assemble and install ***system components*** and ***control components***	***system components*** and ***control components*** are assembled and installed according to manufacturers' specifications and AHJ
C-17.07.05P	label and terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings, specifications, manufacturers' specifications and AHJ
C-17.07.06P	program and test traffic signal lights and controls	program is verified by operation of traffic signal lights and controls according to specifications and client requirements, and test results are documented
C-17.07.07P	service and maintain traffic signal lights and controls	traffic signal lights and ***control components*** are maintained according to client requirements and manufacturers' specifications

C-17.07.08P	determine requirements for removal of existing traffic signal light systems and ***control components***	removal requirements when performing an upgrade are determined according to client requirements and considering impact of removal
C-17.07.09P	remove existing traffic signal lights and ***control components*** when replacing and update documentation	traffic signal lights and ***control components*** are removed and remaining installations are terminated

Range of variables

control components include: vehicle sensors, cameras, traffic signal controllers, modems

system components include: signal heads, luminaires, pedestrian push buttons, audible devices, lighting standards, signal arms, pre-cast bases, traffic signal cables

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-17.07.01L	demonstrate knowledge of traffic signal light systems and ***control components***, their characteristics, applications and operation	identify types of traffic signal light systems and ***control components***, and describe their characteristics and applications
		interpret information pertaining to traffic signal light systems and controls found on drawings and specifications
		interpret codes and regulations pertaining to traffic signal light systems and ***control components***
		identify considerations and requirements for removal of traffic signal light systems and ***control components***
		identify considerations and requirements for selecting traffic signal light systems and ***control components***
C-17.07.02L	demonstrate knowledge of procedures to remove or install, connect and test traffic signal light systems and ***control components***	identify tools and equipment used to remove or install, connect and test traffic signal light systems and ***control components***, and describe their applications and procedures for use
		describe procedures to remove traffic signal lights and ***control components***
		describe procedures to install traffic signal light systems and ***control components***
		describe procedures to connect traffic signal light systems and ***control components***

	describe procedures to service and maintain traffic signal light systems and ***control components***
	describe procedures to test traffic signal light systems and ***control components***, and document results

Range of variables

control components include: vehicle sensors, cameras, traffic signal controllers, modems

Task C-18 Installs, services and maintains power and controls for heating, ventilation and air-conditioning (HVAC) systems

Task descriptor

Heating, ventilation and cooling systems (for the purpose of this task, systems where electricity is not the sole source of energy) are typically installed by other trades but are electrically connected by construction electricians. Construction 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, installation includes both new installations and upgrading of systems by removing and replacing components.

Construction electricians service HVAC system controls by performing visual inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure HVAC system controls are in good operating condition.

C-18.01 Connects HVAC systems and associated equipment

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-18.01.01P	determine connected load requirements	connected load requirements are determined by interpreting nameplate ratings
C-18.01.02P	select branch circuit wiring including disconnect means and overcurrent protection devices	branch circuit wiring, disconnect means and overcurrent protection devices are selected according to location, drawings, specifications, manufacturers' specifications, and client and CEC requirements

C-18.01.03P	select tools and equipment	tools and equipment are selected according to task
C-18.01.04P	install branch circuit wiring including disconnect means and overcurrent protection devices	branch circuit wiring conductors, disconnect means and overcurrent protection devices are identified and installed without damage to insulation and without stress to conductors and cables according to location, drawings, specifications and CEC requirements
C-18.01.05P	terminate and label conductors and cables	conductors and cables are labeled and terminated, and phased and torqued according to manufacturers' specifications, and client and CEC requirements
C-18.01.06P	test operation	operation is verified by testing circuit for specified voltage, current and rotation
C-18.01.07P	determine requirements for disconnection of power source of ***HVAC systems***	disconnection requirements are determined according to client requirements and considering impact disconnection will have on the site
C-18.01.08P	disconnect existing ***HVAC systems*** when replacing and update documentation	***HVAC systems*** are disconnected, remaining installations are terminated, and documentation updated

Range of variables

HVAC systems include: chiller system, compressor unit, fan motor, cooling tower heater, chiller heater

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-18.01.01L	demonstrate knowledge of ***HVAC systems***, their characteristics, applications and operation	identify types of ***HVAC systems***, and describe their characteristics, applications and operation
		interpret information pertaining to ***HVAC systems*** found on drawings, specifications and nameplates
		interpret codes, standards and regulations pertaining to ***HVAC systems***
		identify considerations and requirements for disconnecting ***HVAC systems*** and their components
		identify considerations and requirements for connecting ***HVAC systems*** and their components
C-18.01.02L	demonstrate knowledge of procedures to disconnect or connect ***HVAC systems*** and their components	identify tools and equipment used to disconnect or connect ***HVAC systems*** and their components, and describe their applications and procedures for use

	describe procedures to connect ***HVAC systems*** and their components
	describe procedures to disconnect ***HVAC systems*** and their components

Range of variables

HVAC systems include: chiller system, compressor unit, fan motor, cooling tower heater, chiller heater

C-18.02 Installs HVAC controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-18.02.01P	determine HVAC ***control requirements*** and select ***HVAC control components***	HVAC ***control requirements*** and ***HVAC control components*** are determined according to required ratings and functionality
C-18.02.02P	select tools and equipment	tools and equipment are selected according to task
C-18.02.03P	calculate circuitry and load requirements	calculations are completed according to voltage and current requirements
C-18.02.04P	assemble and install ***HVAC control components***	***HVAC control components*** are assembled and installed according to client requirements and manufacturers' specifications
C-18.02.05P	label and terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ and CEC requirements
C-18.02.06P	program and test ***HVAC control components***	program is verified by operation of ***HVAC control components*** according to specifications and client requirements, and test results are documented
C-18.02.07P	determine requirements for removal of existing ***HVAC control components***	removal requirements for existing ***HVAC control components*** when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-18.02.08P	remove existing ***HVAC control components*** when replacing and update documentation	***HVAC control components*** are removed, remaining installations are terminated, and documentation updated

Range of variables

control requirements include: number and types of functions, occupancy rates

HVAC control components include: thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, time clocks, relays, sensors, actuators, electrical interlocks, multiple function controllers

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

Range of variables

HVAC control components include: thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, time clocks, relays, sensors, actuators, electrical interlocks, multiple function controllers

C-18.03 Performs servicing and maintenance of HVAC systems and controls

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

	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	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
C-18.03.03P	identify and remove defective electrical components and ***equipment*** of ***HVAC systems and controls***	defective electrical components and ***equipment*** of ***HVAC systems and controls*** are removed without damage to system or other components
C-18.03.04P	repair malfunctioning electrical components and ***equipment***	electrical components and ***equipment*** are repaired and tested to ensure they are operational according to manufacturers' specifications
C-18.03.05P	select replacement electrical components and ***equipment***	replacement electrical components and ***equipment*** (OEM replacement when mandated) are selected
C-18.03.06P	install replacement electrical components and ***equipment*** and reprogram	electrical components and ***equipment*** are installed and reprogramed according to manufacturers' specifications
C-18.03.07P	conduct tests of ***HVAC systems and controls*** after repair	***HVAC systems and controls*** are tested after repair, connected and function according to manufacturers' and client specifications
C-18.03.08P	record tests in maintenance schedule	operational problems and test results are documented in maintenance schedule data with detailed notations

Range of variables

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, clamp ammeters, phase rotation meter, thermographic imaging device

equipment includes: air handling motors, evaporator fans, condenser fans

HVAC systems and controls include: chiller system, compressor unit, fan motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, cooling tower heater, chiller heater

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-18.03.01L	demonstrate knowledge of ***HVAC systems and controls,*** their components, characteristics, applications and operation	identify types of ***HVAC systems and controls***, and describe their characteristics, applications and operation
		identify HVAC system and control components, and describe their characteristics and applications
C-18.03.02L	demonstrate knowledge of procedures to service ***HVAC systems and controls***, and their components	identify tools and equipment used to service ***HVAC systems and controls***, and their components, and describe their applications and procedures for use
		describe procedures to diagnose ***HVAC systems and controls***, and their components
		describe procedures to repair ***HVAC systems and controls***, and their components
C-18.03.03L	demonstrate knowledge of procedures to maintain ***HVAC systems and controls***, and their components	identify tools and equipment used to maintain ***HVAC systems and controls***, and their components, and describe their applications and procedures for use
		describe procedures to maintain ***HVAC systems and controls***, and their components

Range of variables

HVAC systems and controls include: chiller system, compressor unit, fan motor, thermostat, pressure switch, temperature switch, flow switch, level switch, VFDs, cooling tower heater, chiller heater

Task C-19 Installs, services and maintains electric heating systems

Task descriptor

Electric heating systems and their associated control devices are installed and connected by construction electricians. Electric heating systems include process and environmental heating in addition to space heating.

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

Construction electricians service electric heating systems and their associated controls by performing visual inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure electric heating systems and their associated control devices are in good operating condition.

C-19.01 Installs electric heating systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-19.01.01P	determine type of ***electric heating system*** required and ***installation requirements***	size and type of ***electric heating system*** and associated ***installation requirements*** are determined according to application and AHJ
C-19.01.02P	calculate demand load, determine branch circuit requirements and reference heat loss calculations	calculations are completed according to voltage and wattage requirements, pre-determined heat loss calculations and CEC requirements
C-19.01.03P	determine installation location for heating device	heating device locations are determined according to manufacturers' specifications and client requirements
C-19.01.04P	select branch circuit wiring	branch circuit wiring is selected according to drawings, specifications, and client and CEC requirements
C-19.01.05P	select tools and equipment	tools and equipment are selected according to task
C-19.01.06P	install branch circuit wiring	branch circuit wiring conductors are identified, selected and installed according to drawings, specifications, and CEC requirements without damage to insulation and without stress to conductors and terminations
C-19.01.07P	install heating device	heating device is installed according to manufacturers' specifications

C-19.01.08P	terminate conductors and cables	conductors and cables are terminated according to CEC requirements, drawings, specifications and AHJ
C-19.01.09P	test operation	operation is verified by testing circuit voltage, current and controls
C-19.01.10P	determine requirements for removal of electric heating systems	removal requirements are determined according to client requirements and considering impact removal will have on facility
C-19.01.11P	remove existing electric heating systems and update documentation	electric heating systems are removed, remaining installations are terminated, and documentation updated

Range of variables

electric heating systems include: electric forced air furnace, electric boiler, convection heaters (baseboard), trace heating cables, duct heater, impedance heating, induction heating, infrared radiant heater, skin-effect heating

installation requirements include: heat loss calculations, available space for heating device, application

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-19.01.01L	demonstrate knowledge of ***electric heating systems***, their components, characteristics, applications and operation	identify types of ***electric heating systems***, and describe their characteristics, applications and operation
		identify electric heating system components, and describe their characteristics and applications
		interpret codes, regulations and standards pertaining to ***electric heating systems***
		interpret information pertaining to ***electric heating systems*** found on drawings and specifications
		identify considerations and requirements for removal of ***electric heating systems*** and their components
		identify considerations and requirements for selecting ***electric heating systems*** and their components
C-19.01.02L	demonstrate knowledge of procedures to remove and install ***electric heating systems*** and their components	identify tools and equipment used to remove and install ***electric heating systems*** and their components, and describe their applications and procedures for use
		describe procedures to calculate heat loss

	describe procedures to remove ***electric heating systems*** and their components
	describe procedures to install ***electric heating systems*** and their components

Range of variables

electric heating systems include: electric forced air furnace, electric boiler, convection heaters (baseboard), trace heating cables, duct heater, impedance heating, induction heating, infrared radiant heater, skin-effect heating

C-19.02 Installs electric heating system controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-19.02.01P	determine ***electric heating system control components*** required	***electric heating system control components*** are selected according to required rating and functionality for application
C-19.02.02P	select tools and equipment	tools and equipment are selected according to task
C-19.02.03P	calculate circuitry and load requirements	calculations are completed according to voltage and wattage requirements
C-19.02.04P	assemble and install ***electric heating system control components***	***electric heating system control components*** are assembled and installed according to client and manufacturers' specifications
C-19.02.05P	label and terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ and CEC requirements
C-19.02.06P	program and test ***electric heating system control components***	program is verified by operation of ***electric heating system control components*** according to specifications and client requirements
C-19.02.07P	determine requirements for removal of existing electric heating system controls	removal requirements when performing an upgrade are determined according to client requirements and considering impact removal will have on facility
C-19.02.08P	remove existing ***electric heating system control components*** when replacing and update documentation	***electric heating system control components*** are removed, remaining installations are terminated, and documentation updated

Range of variables

control requirements include: number and types of functions

electric heating system control components include: thermostats, relays, sensors, contactors, electrical interlocks, analog and digital controls, automated controls (internet of things, energy management), smart controls

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-19.02.01L	demonstrate knowledge of ***electric heating system control components***, their characteristics and applications	identify types of ***electric heating system control components***, and describe their characteristics and applications
		interpret information pertaining to ***electric heating system control components*** found on drawings and specifications
		interpret codes and regulations pertaining to ***electric heating system control components***
		identify considerations and requirements for removal of ***electric heating system control components***
		identify considerations and requirements for selecting ***electric heating system control components***
C-19.02.02L	demonstrate knowledge of procedures to remove, install, connect and test ***electric heating system control components***	identify tools and equipment used to remove, install, connect and test ***electric heating system control components***, and describe their applications and procedures for use
		describe procedures to remove ***electric heating system control components***
		describe procedures to install ***electric heating system control components***
		describe procedures to connect ***electric heating system control components***
		describe procedures to test ***electric heating system control components***

Range of variables

electric heating system control components include: thermostats, relays, sensors, contactors, electrical interlocks, analog and digital controls, automated controls (internet of things, energy management), smart controls

C-19.03 Performs servicing and maintenance of electric heating systems and controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-19.03.01P	select tools and equipment	tools and equipment are selected according to task
C-19.03.02P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
C-19.03.03P	identify and remove defective ***electric heating system control components*** and controls	defective ***electric heating system control components*** and controls are removed without damage to system or other components
C-19.03.04P	select replacement ***electric heating system control components***	replacement ***electric heating system control components*** (OEM replacement when mandated) are selected
C-19.03.05P	install replacement ***electric heating system control components***	replacement ***electric heating system control components*** are installed according to manufacturers' specifications
C-19.03.06P	conduct tests of ***electric heating system control components*** after repair	***electric heating system control components*** are tested, connected and function according to manufacturers' and client specifications
C-19.03.07P	clean and adjust ***electric heating system control components***	***electric heating system control components*** are cleaned, adjusted and restored to optimal conditions
C-19.03.08P	record tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data with detailed notations

Range of variables

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, clamp ammeters, thermographic imaging devices, thermometer, insulation resistance tester

electric heating system control components include: thermostats, relays, sensors, contactors, electrical interlocks, analog and digital controls, automated controls (internet of things, energy management), smart controls

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-19.03.01L	demonstrate knowledge of ***electric heating systems*** and ***electric heating system control components***, and their characteristics, applications and operation	identify types of ***electric heating systems*** and ***electric heating system control components***, and describe their characteristics, applications and operation
		identify ***electric heating systems*** and ***electric heating system control components***, and describe their characteristics and applications
C-19.03.02L	demonstrate knowledge of procedures to service ***electric heating systems*** and ***electric heating system control components***	identify tools and equipment used to service ***electric heating systems*** and ***electric heating system control components***, and describe their applications and procedures for use
		describe procedures to diagnose ***electric heating systems*** and ***electric heating system control components***
		describe procedures to repair ***electric heating systems*** and ***electric heating system control components***
C-19.03.03L	demonstrate knowledge of procedures to maintain ***electric heating systems*** and ***electric heating system control components***	identify tools and equipment used to maintain ***electric heating systems*** and ***electric heating system control components***, and describe their applications and procedures for use
		describe procedures to maintain ***electric heating systems*** and ***electric heating system control components***

Range of variables

electric heating systems include: electric forced air furnace, electric boiler, convection heaters, radiant heaters, heat tracing cables, duct heater, heating cables

electric heating system control components include: thermostats, relays, sensors, contactors, electrical interlocks, analog and digital controls, automated controls (internet of things, energy management), smart controls

Task C-20 Installs, services and maintains exit and emergency lighting systems

Task descriptor

Exit and emergency lighting systems are used to facilitate safe egress (exit) from buildings and access to exit during emergency situations. The systems can be powered by batteries or generators and the required size and placement are determined by building code requirements. Construction electricians install exit and emergency lighting systems.

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

Construction electricians service exit and emergency lighting systems by performing visual inspections, troubleshooting, diagnosing faults, and repairing them. They also perform maintenance to ensure exit and emergency lighting systems are in good operating condition.

C-20.01 Installs exit and emergency lighting

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-20.01.01P	determine type and installation requirements of ***exit and emergency lighting system*** required	size, type and installation requirements of ***exit and emergency lighting system*** are determined according to drawings, specifications and building code requirements
C-20.01.02P	calculate connected load	connected load is calculated considering voltage drop according to manufacturers' specifications, and CEC and AHJ requirements
C-20.01.03P	determine branch circuit requirements and standby energy source	branch circuit requirements and standby energy source are determined according to manufacturers' specifications, and CEC and AHJ 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 branch circuit wiring	branch circuit wiring is selected according to CEC requirements
C-20.01.06P	select tools and equipment	tools and equipment are selected according to task

C-20.01.07P	install branch circuit wiring	branch circuit wiring conductors are identified, selected and installed according to drawings, specifications, manufacturers' specifications, CEC and AHJ requirements, without damage to insulation, and without stress to conductors and terminations
C-20.01.08P	install ***exit and emergency lighting system***	***exit and emergency lighting system*** is installed according to manufacturers' specifications and AHJ requirements
C-20.01.09P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications and CEC requirements
C-20.01.10P	test operation and complete documentation	operation is verified by testing circuit for specified voltage, lighting levels and duration of operation according to AHJ requirements, and test results are documented
C-20.01.11P	determine requirements for removal of ***exit and emergency lighting system***	removal requirements for ***exit and emergency lighting system*** are determined according to AHJ and client requirements, and considering impact removal will have on facility
C-20.01.12P	remove and dispose of existing ***exit and emergency lighting system*** when replacing and update documentation	***exit and emergency lighting system*** is removed and disposed of and remaining installations are terminated according to CEC requirements, and documentation updated

Range of variables

exit and emergency lighting systems include: unit equipment, central-powered, remote lighting units, automatic emergency power transfer control relays

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-20.01.01L	demonstrate knowledge of ***exit and emergency lighting systems,*** their components, characteristics, applications and operation	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 characteristics and applications
		interpret codes, regulations and standards pertaining to ***exit and emergency lighting systems***
		interpret information pertaining to ***exit and emergency lighting systems*** found on drawings and specifications

		identify considerations and requirements for removal and disposal of ***exit and emergency lighting systems***, and their components
		identify considerations and requirements for selecting ***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 procedures to install ***exit and emergency lighting systems***, and their components
		describe procedures to test ***exit and emergency lighting systems***, and their components, and identify required documentation to be completed

Range of variables

exit and emergency lighting systems include: unit equipment , central-powered, remote lighting units, automatic emergency power transfer control relays

C-20.02 Performs servicing and maintenance of exit and emergency lighting systems

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

	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	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
C-20.02.03P	identify, remove and dispose of defective components	defective component removed and disposed of without damage to system or other components

C-20.02.04P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications and AHJ
C-20.02.05P	select replacement components	replacement components (OEM replacement when mandated) are selected
C-20.02.06P	install replacement components	replacement components are installed according to manufacturers' specifications
C-20.02.07P	conduct tests of ***exit and emergency lighting system*** after repair	***exit and emergency lighting system*** is tested after repair and functions according to AHJ mandated lighting levels and duration of operation
C-20.02.08P	record tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data with detailed notations
C-20.02.09P	identify, remove, 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

Range of variables

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters, lux meter, ammeter

exit and emergency lighting systems include: unit equipment, central-powered, remote lighting units, automatic emergency power transfer control relays

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-20.02.01L	demonstrate knowledge of ***exit and emergency lighting systems***, their components, characteristics, applications and operation	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
C-20.02.02L	demonstrate knowledge of procedures to service ***exit and emergency lighting systems***	identify tools and equipment used to service ***exit and emergency lighting systems***, and describe their applications and procedures for use
		describe procedures to diagnose ***exit and emergency lighting systems***, and their components
		describe procedures to repair or replace ***exit and emergency lighting systems***, and their components

C-20.02.03L	demonstrate knowledge of procedures to maintain ***exit and emergency lighting systems***, 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 ***exit and emergency lighting systems***, and their components

Range of variables

exit and emergency lighting systems include: unit equipment, central-powered, remote lighting units, automatic emergency power transfer control relays

Task C-21 Installs, services and maintains cathodic protection systems

Task descriptor

Cathodic protection systems introduce a current onto a tank, pipe or structure to limit corrosion and oxidization. Construction electricians install these systems in various environments according to specifications.

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

Construction electricians service cathodic protection systems by performing visual inspections, troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure cathodic protection systems are in good operating condition.

C-21.01 Installs cathodic protection systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-21.01.01P	determine installation location for ***cathodic protection systems***	***cathodic protection system*** locations are determined according to manufacturers' specifications and client requirements
C-21.01.02P	select branch circuit wiring	branch circuit wiring is selected according to industry 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 colour-coded, selected and installed according to drawings, specifications and CEC requirements, without damage to insulation, and without stress to conductors and terminations
C-21.01.05P	install ***cathodic protection systems***	***cathodic protection systems*** are installed according to manufacturers' specifications
C-21.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and engineering, AHJ and CEC requirements
C-21.01.07P	test operation	operation is verified by checking reference points and testing circuit for specified voltage and current levels for complete installation
C-21.01.08P	determine requirements for removal of ***cathodic protection systems***	removal requirements for ***cathodic protection systems*** are determined according to client requirements and considering impact removal will have on installation
C-21.01.09P	remove existing ***cathodic protection systems*** when replacing and update documentation	***cathodic protection systems*** are removed, remaining installations are isolated and documentation updated

Range of variables

cathodic protection systems include: rectifier, sacrificial anode, disconnecting means, warning signs

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-21.01.01L	demonstrate knowledge of ***cathodic protection systems*** and ***cathodic protection system components***, their characteristics, applications and operation	identify types of ***cathodic protection systems***, and describe their characteristics, applications and operation
		identify ***cathodic protection system components***, and describe their characteristics, applications and operation
		interpret information pertaining to ***cathodic protection systems*** found on drawings and specifications
		interpret codes and regulations pertaining to ***cathodic protection systems***
C-21.01.02L	demonstrate knowledge of procedures to install, connect and test ***cathodic protection systems*** and ***cathodic protection system components***	identify tools and equipment used to install, connect and test ***cathodic protection systems***, and describe their applications and procedures for use

	describe procedures to install ***cathodic protection systems*** and ***cathodic protection system components***
	describe procedures to connect ***cathodic protection systems*** and ***cathodic protection system components***
	describe procedures to test ***cathodic protection systems*** and ***cathodic protection system components***

Range of variables

cathodic protection systems include: rectifier, sacrificial anode, disconnecting means, warning signs
cathodic protection system components include: rectifier, insulation kits, cabling, breaker, anode connection conductors, remote reference points, tap settings in rectifier enclosure, jumpers, transformers

C-21.02 Performs servicing and maintenance of cathodic protection systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
C-21.02.01P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
C-21.02.02P	select tools and equipment	tools and equipment are selected according to task
C-21.02.03P	identify and remove defective ***cathodic protection system components***	defective ***cathodic protection system components*** are removed without damage to system or other components
C-21.02.04P	repair malfunctioning ***cathodic protection system components*** and verify repair	***cathodic protection system components*** are repaired and tested to ensure they are operational according to manufacturers' specifications
C-21.02.05P	select replacement ***cathodic protection system components***	replacement ***cathodic protection system components*** (OEM replacement when mandated) are selected
C-21.02.06P	install replacement ***cathodic protection system components***	replacement ***cathodic protection system components*** are installed according to manufacturers' specifications

C-21.02.07P	conduct tests of ***cathodic protection systems*** after repair	***cathodic protection systems*** are tested after repair, connected and function according to manufacturers' specifications
C-21.02.08P	record tests in maintenance schedule	operational problems and tests are documented in maintenance schedule data with detailed notations

Range of variables

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: multimeters

cathodic protection system components include: rectifier, insulation kits, cabling, breaker, anode connection conductors, remote reference points, tap settings in rectifier enclosure, jumpers, transformers

cathodic protection systems include: rectifier, sacrificial anode, disconnecting means and warning signs

	Knowledge	
	Learning Outcomes	**Learning Objectives**
C-21.02.01L	demonstrate knowledge of ***cathodic protection systems***, ***cathodic protection system components***, their characteristics, applications and operation	identify types of ***cathodic protection systems*** and ***cathodic protection system components***, and describe their characteristics, applications and operation
C-21.02.02L	demonstrate knowledge of procedures to service and maintain ***cathodic protection systems***	identify tools and equipment used to service and maintain ***cathodic protection systems***, and describe their applications and procedures for use
		describe procedures to diagnose and repair ***cathodic protection systems***
		describe procedures to maintain ***cathodic protection systems***

Range of variables

cathodic protection systems include: rectifier, sacrificial anode, disconnecting means and warning signs

cathodic protection system components include: rectifier, insulation kits, cabling, breaker, anode connection conductors, remote reference points, tap settings in rectifier enclosure, jumpers, transformers

Major Work Activity D

Installs, services and maintains motors and control systems

Task D-22 Installs, services and maintains motor starters and controls

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. Construction electricians install, service 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, installation includes both new installations and upgrading of systems by removing and replacing components.

Construction electricians service motor starters and controls by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure motor starters and controls are in good operating condition.

D-22.01 Installs motor starters

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-22.01.01P	determine type and function of ***motor starter*** for specific application	***motor starter*** type and function is selected according to specific application, drawings, specifications, and client and CEC requirements
D-22.01.02P	determine size of ***motor starter***	size of ***motor starter*** is determined according to motor ***manufacturers' nameplate data***
D-22.01.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements
D-22.01.04P	select tools and equipment	tools and equipment are selected according to task

D-22.01.05P	position, mount and assemble ***starter assembly***	***starter assembly*** is placed in locations according to drawings, and job and client requirements
D-22.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications and CEC requirements
D-22.01.07P	set up and adjust motor overloads	motor overloads are set up and adjusted according to application and CEC requirements
D-22.01.08P	interconnect ***motor starter*** with ***peripheral devices***	interconnections are completed and equipment functions as intended
D-22.01.09P	conduct tests of ***motor starter*** after installation and record results	***motor starter*** is tested after installation, connected and functions according to manufacturers' and client specifications, and results documented
D-22.01.10P	remove existing equipment when replacing and update documentation	existing equipment is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self-protected combination motor controller

manufacturers' nameplate data includes: size of motor (horsepower), full load current (FLC), service factor, voltage (AC/DC, number of phases), duty, starter size (NEMA, IEC), insulation classification, multi-voltage, speed

starter assembly includes: enclosures, control transformers, overcurrent protection, overload protection, terminations

peripheral devices include: start/stop stations, emergency stop stations, limit switches

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-22.01.01L	demonstrate knowledge of ***motor starters,*** their components, accessories, characteristics, applications, and operation	interpret information pertaining to ***motor starters*** found on ***manufacturers' nameplate data***, drawings and specifications
		identify ***motor starters*** and their components and accessories, and describe their characteristics, applications, and operation
		interpret codes and regulations pertaining to ***motor starters***
D-22.01.02L	demonstrate knowledge of procedures to install and connect ***motor starters***, their components and accessories	identify tools and equipment used to install and connect ***motor starters***, their components and accessories, and describe their applications and procedures for use

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

Range of variables

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self-protected combination motor controller

manufacturers' nameplate data includes: size of motor (horsepower), full load current (FLC), service factor, voltage (AC/DC, number of phases), duty, starter size (NEMA, IEC), insulation classification, multi-voltage, speed

D-22.02 Performs servicing and maintenance of motor starters

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-22.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
D-22.02.02P	select tools and equipment	tools and equipment are selected according to task
D-22.02.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
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 and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
D-22.02.06P	select replacement components	replacement components (OEM replacement when mandated) are selected
D-22.02.07P	install replacement components	replacement components are installed according to manufacturers' specifications
D-22.02.08P	conduct tests of motor starters after repair	starter assembly is tested after repair, connected and functions according to manufacturers' and client specifications

D-22.02.09P	clean and ***adjust*** components	components are cleaned and ***adjusted*** to restore to optimal ***conditions***
D-22.02.10P	record tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data with detailed notations
D-22.02.11P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

adjust includes: inspection of terminations, overload settings, timing settings

conditions include: no foreign material build-up, manufacturer specified contact pressure, no carbon build-up, no pitting on contacts

field assessments include: sensory inspections, technical inspections

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-22.02.01L	demonstrate knowledge of ***motor starters,*** their components, accessories, characteristics, applications, and operation	interpret information pertaining to ***motor starters*** found on drawings and specifications
		identify ***motor starters***, their components and accessories, and describe their characteristics, applications, and operation
		interpret codes and regulations pertaining to ***motor starters***
D-22.02.02L	demonstrate knowledge of procedures to service and maintain ***motor starters***	identify tools and equipment used to service and maintain ***motor starters***, and describe their applications and procedures for use
		describe procedures to service ***motor starters***, their components and accessories
		describe procedures to maintain ***motor starters***, their components and accessories

Range of variables

motor starters include: line voltage starters, dual speed starter, forward/reverse starter, soft starters, reduced-voltage starters, self-protected combination motor controller

D-22.03 Installs motor control devices

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-22.03.01P	determine type of ***motor control devices*** and ***function***	***motor control devices*** are selected according to specific application
D-22.03.02P	determine ***motor control circuit*** types required for specific application	***motor control circuit*** types are selected according to specific application
D-22.03.03P	calculate conductor and cable requirements	conductor and cable quantity, type and size are calculated according to CEC requirements
D-22.03.04P	select tools and equipment	tools and equipment are selected according to task
D-22.03.05P	position, mount and assemble ***motor control device***	***motor control device*** is placed in locations according to drawings, and job and client requirements
D-22.03.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications and CEC requirements
D-22.03.07P	set up and adjust ***motor control devices***	***motor control devices*** operate according to application and intended function
D-22.03.08P	interconnect ***motor control devices*** with ***peripheral devices***	***motor control devices*** are interconnected to ***peripheral devices***, and equipment functions as intended
D-22.03.09P	interconnect ***motor control devices*** with overload protection	**motor control devices** are interconnected to overload protection and equipment functions as intended
D-22.03.10P	conduct tests of ***motor control devices*** after installation and record results	***motor control devices*** are tested after installation, connected and function according to manufacturers' and client specifications
D-22.03.11P	remove existing equipment when replacing and update documentation	equipment is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

circuit 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)

peripheral devices include: indicating lights, audible devices

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-22.03.01L	demonstrate knowledge of ***motor control devices***, their characteristics, applications and operation	interpret information pertaining to ***motor control devices*** found on drawings and specifications
		identify ***motor control devices***, and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to ***motor control devices***
D-22.03.02L	demonstrate knowledge of ***motor control circuits***, their characteristics and applications	interpret codes and regulations pertaining to ***motor control circuits***
		identify ***circuit types***, and describe their characteristics and applications
		describe ***circuit functional features*** of motor control circuits
		identify methods used to determine number of conductors required between controls and controller locations
		identify **motor *protection devices***, and describe their characteristics and applications
D-22.03.03L	demonstrate knowledge of procedures to install ***motor control devices***	identify tools and equipment used to install ***motor control devices***, and describe their applications and procedures for use
		describe procedures to install ***motor control devices***

Range of variables

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

motor control circuits include: low-voltage release (two-wire control), low-voltage protection (three-wire control)

circuit functional features include: starting and stopping, forward/reverse, sequencing, jogging, quick stop (plugging), multiple location control, time function

motor protection devices include: overload, overheating, phase loss, phase reversal

D-22.04 Performs servicing and maintenance of motor controls

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-22.04.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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 ***field assessments*** and ***diagnostic and test equipment*** results
D-22.04.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-22.04.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
D-22.04.06P	install replacement components	replacement components are installed according to manufacturers' specifications
D-22.04.07P	conduct tests of motor controls after repair	control assembly is tested after repair, connected and functions according to manufacturers' and client specifications
D-22.04.08P	clean, lubricate and ***adjust*** components	motor control devices are cleaned, lubricated and ***adjusted*** according to manufacturers' specifications to restore to optimal ***conditions***

D-22.04.09P	record tests in maintenance schedule	operational problems and test results are identified in maintenance schedule data with detailed notations
D-22.04.10P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

field assessments include: sensory inspections, technical inspections

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

adjustments include: inspecting terminations, calibration of components

conditions include: no foreign material build-up, manufacturer specified contact pressure, no carbon build-up, no pitting on contacts

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-22.04.01L	demonstrate knowledge of ***motor control devices,*** their components, characteristics, applications and operation	interpret information pertaining to ***motor control devices*** found on drawings and specifications
		identify types of ***motor control devices*** and components, and describe their characteristics, applications and operation
		interpret codes and regulations pertaining to ***motor control devices***
D-22.04.02L	demonstrate knowledge of procedures to service and maintain ***motor control devices***	identify tools and equipment used to service and maintain ***motor control devices***, and describe their applications and procedures for use
		describe procedures to service ***motor control devices*** and their components
		describe procedures to maintain ***motor control devices*** and their components

Range of variables

motor control devices include: emergency stop stations, start/stop stations, PLCs, pilot devices (limit switches, proximity switches, float switches, sail switches, photo detectors)

Task D-23 Installs, services and maintains drives

Task descriptor

Electrical motors can be controlled by both AC and DC drives to achieve precision operation (speed, positioning) of the motors depending on the application. Construction electricians install, service and maintain these drives in the motor circuits.

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, installation includes both new installations and upgrading of systems by removing and replacing components.

Construction electricians service motor drives by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure motor starters and controls are in good operating condition.

D-23.01 Installs AC drives

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-23.01.01P	determine type of AC drive for specific application	AC drive is selected according to specific application
D-23.01.02P	determine size and function of AC drive	size and function of AC drive are determined according to ***manufacturers' nameplate data***
D-23.01.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to ***special conditions*** and CEC requirements
D-23.01.04P	select tools and equipment	tools and equipment are selected according to task
D-23.01.05P	position, mount and assemble AC drives	AC drive is positioned, mounted and assembled in locations according to drawings, and job and client requirements
D-23.01.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications and CEC requirements
D-23.01.07P	calibrate and program AC drives	calibration and programming meet functionality and equipment parameters
D-23.01.08P	interconnect AC drives with ***peripheral devices***	AC drives are interconnected to ***peripheral devices*** with required cables, raceways and conductors, and equipment functions as intended

D-23.01.09P	conduct tests of AC drive after installation and record results	AC drive is tested after installation, connected and functions according to manufacturers' and client specifications, and results documented
D-23.01.10P	remove existing AC drives when replacing and update documentation	existing AC drive is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

manufacturers' nameplate data includes: size of motor (horsepower), full load current (FLC), inverter duty rated, voltage, frequency, speed/rpm

special conditions include: shielding requirements, length of cable, type of VFD rated cable, reactor use, equipment bonding

peripheral devices include: start/stop stations, emergency stop stations, speed control, sensing devices, encoders, tachometers, limit switches

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-23.01.01L	demonstrate knowledge of AC drives, ***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, ***AC drive components*** and accessories
D-23.01.02L	demonstrate knowledge of procedures to install and connect AC drives, ***AC drive components*** and accessories	identify tools and equipment used to install and connect AC drives, ***AC drive components*** and accessories, and describe their applications and procedures for use
		describe procedures to install AC drives, ***AC drive components*** and accessories
		describe procedures to connect AC drives, ***AC drive components*** and accessories
		describe procedures to adjust AC drives, ***AC drive components*** and accessories

Range of variables

AC drive components include: rectifiers, electro-magnetic compatibility (EMC) filters, DC circuits, inverters, shielded cables

D-23.02 Performs servicing and maintenance of AC drives

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-23.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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 ***field assessments*** and ***diagnostic and test equipment*** results
D-23.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-23.02.05P	repair malfunctioning components and verify repair	components are repaired and tested to ensure they are operational according to manufacturers' specifications
D-23.02.06P	select replacement components	replacement components (OEM replacement when mandated) are selected
D-23.02.07P	install replacement components	replacement components are installed according to manufacturers' specifications
D-23.02.08P	adjust programming after repair or for new operating conditions	programming is adjusted according to type of repair and changes in operating conditions
D-23.02.09P	conduct ***tests*** of AC drives after repair	AC drive assembly is tested after repair, connected and functions according to manufacturers' and client specifications
D-23.02.10P	***clean and adjust*** components	AC drive components are ***cleaned and adjusted*** to restore to optimal conditions
D-23.02.11P	record ***tests*** in maintenance schedule	operational problems and ***test*** results are documented in maintenance schedule data with detailed notations
D-23.02.12P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

cleaning and adjustment procedures include: inspecting terminations, cleaning filters and cooling fans, checking door seals

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

tests include: conductance test of power semiconductors, confirm speed/rpm

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-23.02.01L	demonstrate knowledge of AC drives, ***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
D-23.02.02L	demonstrate knowledge of procedures to service and maintain AC drives, ***AC drive components*** and accessories	identify tools and equipment used to service and maintain AC drives, ***AC drive components*** and accessories, and describe their applications and procedures for use
		describe procedures to service and maintain AC drives, ***AC drive components*** and accessories

Range of variables

AC drive components include: rectifiers, EMC filters, DC circuits, inverters, IGBTs (insulated gate bipolar transistors)

D-23.03 Installs DC drives

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-23.03.01P	determine type of DC drive for specific application	DC drive is selected and sized according to specific application
D-23.03.02P	determine size and function of DC drive	size and function of DC drive are determined according to ***manufacturers' nameplate data***
D-23.03.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to ***special conditions*** and CEC requirements
D-23.03.04P	select tools and equipment	tools and equipment are selected according to task
D-23.03.05P	position, mount and assemble DC drives	DC drive is positioned, mounted and assembled in locations according to drawings, and job and client requirements
D-23.03.06P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications and CEC requirements
D-23.03.07P	calibrate and program DC drives	calibration and programming of DC drives meets functionality and established parameters
D-23.03.08P	interconnect DC drives with ***peripheral devices***	DC drives are interconnected to ***peripheral devices*** with required cables, raceways and conductors, and equipment functions as intended
D-23.03.09P	conduct tests of DC drive after installation and record results	DC drive is tested after installation, connected and functions according to manufacturers' and client specifications, and results are documented
D-23.03.10P	remove existing DC drives when replacing and update documentation	DC drive is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

manufacturers' nameplate data includes: size of motor (horsepower), FLA, voltage, speed/rpm

special conditions include: shielding requirements, length of cable, line reactor

peripheral 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, ***DC drive components***, their accessories, characteristics, applications and operation	identify types of DC drives, and describe their characteristics, applications and operation
		identify ***DC drive components*** and accessories, 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, ***DC drive components*** and accessories
D-23.03.02L	demonstrate knowledge of procedures to install and connect DC drives, ***DC drive components*** and accessories	identify tools and equipment used to install and connect DC drives, ***DC drive components*** and accessories, and describe their applications and procedures for use
		describe procedures to install DC drives, ***DC drive components*** and accessories
		describe procedures to connect DC drives, ***DC drive components*** and accessories
		describe procedures to adjust DC drives, ***DC drive components*** and accessories

Range of variables

DC drive components include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, field components (encoders, tachometers)

D-23.04 Performs servicing and maintenance of DC drives

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-23.04.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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 ***field assessments*** and ***diagnostic and test equipment*** results
D-23.04.04P	identify and remove defective ***DC drive components***	defective ***DC drive components*** are removed without damage to system or other components
D-23.04.05P	repair malfunctioning ***DC drive components*** and verify repair	***DC drive components*** are repaired and tested to ensure they are operational according to manufacturers' specifications
D-23.04.06P	select replacement ***DC drive components***	replacement ***DC drive components*** (OEM replacement when mandated) are selected
D-23.04.07P	install replacement ***DC drive components***	replacement ***DC drive components*** are installed according to manufacturers' specifications
D-23.04.08P	conduct tests of DC drives after repair	DC drive assembly is tested after repair, connected and functions according to manufacturers' and client specifications
D-23.04.09P	***clean and adjust DC drive components***	***DC drive components*** are ***cleaned and adjusted*** to restore to optimal conditions
D-23.04.10P	record tests in maintenance schedule	operational problems and test results are documented in maintenance schedule data
D-23.04.11P	compare and analyze maintenance test results	maintenance is performed according to test results and comparison with specifications

Range of variables

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

field assessments include: sensory inspections, technical inspections

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

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, field components (encoders, tachometers)

cleaning and adjustment procedures include: inspecting terminations, cleaning filters and cooling fans, checking door seals

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-23.04.01L	demonstrate knowledge of DC drives, ***DC drive components, their*** accessories, characteristics, applications and operation	identify types of DC drives, and describe their characteristics, applications and operation
		identify ***DC drive components*** and accessories, 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 service and maintain DC drives, ***DC drive components*** and accessories	identify tools and equipment used to service and maintain DC drives, ***DC drive components*** and accessories, and describe their applications and procedures for use
		describe procedures to service and maintain DC drives, ***DC drive components*** and accessories

Range of variables

DC drive components include: power supply, converters, speed controls, tension controls, torque controls, EMC filters, DC circuits, control boards, power semi-conductors, enclosure components, feedback loops, field components (encoders, tachometers)

Task D-24 Installs, services and maintains motors

Task descriptor

Motors are used to convert electrical energy to mechanical energy. Construction electricians install, service and maintain single-phase, three-phase and DC motors.

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

Construction electricians service motors by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure motors are in good operating condition.

D-24.01 Installs single-phase motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.01.01P	determine type of ***single-phase motor*** required	type of ***single-phase motor*** is selected according to ***criteria for operation***
D-24.01.02P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements
D-24.01.03P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to requirements such that motor is protected
D-24.01.04P	select tools and equipment	tools and equipment are selected according to task
D-24.01.05P	position and mount ***single-phase motor***	***single-phase motor*** is positioned and mounted according to application
D-24.01.06P	terminate motor leads	motor leads are terminated according to application
D-24.01.07P	conduct tests of ***single-phase motor*** after installation and document results	***single-phase motor*** is tested after installation, connected and functions according to manufacturers' and client specifications, and results documented
D-24.01.08P	remove existing ***single-phase motor*** when replacing and update documentation	***single-phase motor*** is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

single-phase motors include: hermetically sealed, dual capacitor, capacitor start/induction run, split phase, universal, resistance split phase, permanent split capacitor, shaded pole

criteria for operation of single-phase motors include: voltage availability, motor function, rotation, environment

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.01.01L	demonstrate knowledge of ***single-phase motors***, ***single-phase motor components***, their characteristics, applications and operation	identify types of ***single-phase motors***, and describe their characteristics, applications and operation
		identify ***single-phase motor components***, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***single-phase motors***
		interpret information pertaining to ***single-phase motors*** found on drawings and specifications
		explain construction and operating principles of ***single-phase motors***
		interpret information contained on single-phase motor nameplates
D-24.01.02L	demonstrate knowledge of procedures to install and connect ***single-phase motors*** and ***single-phase motor components***	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 ***single-phase motors*** and ***single-phase motor components***
		describe procedures to connect ***single-phase motors*** and ***single-phase motor components***
		identify ***coupling methods*** for ***single-phase motors***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***single-phase motors*** and ***single-phase motor components***

Range of variables

single-phase motors include: hermetically sealed, dual capacitor, capacitor start/induction run, split phase, universal, resistance split phase, permanent split capacitor, shaded pole

single-phase motor components include: frame, centrifugal switch, rotor, stator, end bells, fans, brushes, bearings, bushings

coupling methods include: flexible couplings, fixed couplings, magnetic couplings, transmissions, belts and pulleys, sprockets and chains

D-24.02 Performs servicing and maintenance of single-phase motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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 ***field assessments*** and ***diagnostic and test equipment*** results
D-24.02.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-24.02.05P	select replacement components	replacement components (OEM replacement when mandated) are selected
D-24.02.06P	install replacement components	replacement components are installed according to manufacturers' specifications
D-24.02.07P	conduct tests of single-phase motors after repair	single-phase motor assembly is tested after repair, connected and functions according to specifications and application
D-24.02.08P	***clean, lubricate and adjust*** components	single-phase motor components are ***cleaned, lubricated and adjusted*** to restore to optimal conditions
D-24.02.09P	record ***tests*** in maintenance schedule	operational problems and ***test*** results are documented in maintenance schedule data
D-24.02.10P	compare and analyze maintenance test results	maintenance is performed according to test results and specifications

Range of variables

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

field assessments include: sensory inspections, technical inspections

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

cleaning, lubrication and adjustment procedures include: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches

tests include: vibration, insulation, current, rotation, alignment, voltage

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.02.01L	demonstrate knowledge of ***single-phase motors***, ***single-phase motor components***, their characteristics, applications and operation	identify types of ***single-phase motors***, and describe their characteristics, applications and operation
		identify ***single-phase motor components*** and accessories, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***single-phase motors***
		interpret information pertaining to ***single-phase motors*** found on drawings and specifications
		explain construction and operating principles of ***single-phase motors***
		interpret information contained on single-phase motor nameplates
D-24.02.02L	demonstrate knowledge of procedures to service and maintain ***single- phase motors*** and ***single-phase motor components***	identify tools and equipment used to service and maintain ***single- phase motors*** and ***single-phase motor components***, and describe their applications and procedures for use
		describe procedures to service ***single-phase motors*** and ***single-phase motor components***
		describe procedures to maintain ***single-phase motors*** and ***single-phase motor components***

Range of variables

single-phase motors include: hermetically sealed, dual capacitor, capacitor start/induction run, split phase, universal, permanent split capacitor, shaded pole

single-phase motor components include: frame, centrifugal switch, rotor, stator, end bells, fans, brushes, bearings, bushings

D-24.03 Installs three-phase motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.03.01P	determine type of ***three-phase motor*** required	type of ***three-phase motor*** is selected according to ***criteria for operation***
D-24.03.02P	select tools and equipment	tools and equipment are selected according to task
D-24.03.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements
D-24.03.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to CEC requirements
D-24.03.05P	determine and install ***motor protection devices***	***motor protection devices*** are installed such that motor is protected
D-24.03.06P	position and mount ***three-phase motor***	***three-phase motor*** is mounted according to application
D-24.03.07P	terminate motor leads	motor leads are terminated according to application
D-24.03.08P	conduct ***tests*** of ***three-phase motors*** after installation and record results	***three-phase motors*** are tested after installation, connected and function according to specifications and application, and results documented
D-24.03.09P	remove existing ***three-phase motors*** when replacing and update documentation	existing ***three-phase motors*** are removed with minimal impact to environment and drawings reflect operational changes

Range of variables

three-phase motors include: squirrel cage induction, synchronous, wound rotor induction
criteria for operation includes: voltage availability, motor function, rotation, location
motor protection devices include: phase loss/reversal protection, high temperature sensors
tests include: vibration, insulation, current, rotation, alignment, voltage

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.03.01L	demonstrate knowledge of ***three-phase motors***, their components, characteristics, applications and operation	identify types of ***three-phase motors***, and describe their characteristics, applications and operation
		identify three-phase motor components, and describe their characteristics and applications

		interpret codes and regulations pertaining to ***three-phase motors***
		interpret information pertaining to ***three-phase motors*** found on drawings and specifications
		explain construction and operating principles of ***three-phase motors***
		interpret information contained on three-phase motor nameplates
		identify considerations and requirements for selecting ***three-phase motors*** and their components
D-24.03.02L	demonstrate knowledge of procedures to install and connect ***three-phase motors*** and their components	identify tools and equipment used to install and connect ***three-phase motors*** and their components, and describe their applications and procedures for use
		describe procedures to install ***three-phase motors*** and their components
		describe procedures to connect ***three-phase motors*** and their components
		identify ***coupling methods*** for ***three-phase motors***, and describe their characteristics and applications

Range of variables

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

coupling methods include: flexible couplings, fixed couplings, magnetic couplings, transmissions, belts and pulleys, sprockets and chains

D-24.04 Performs servicing and maintenance of three-phase motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.04.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
D-24.04.02P	select tools and equipment	tools and equipment are selected according to task
D-24.04.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results

D-24.04.04P	identify and remove defective components	defective components are removed without damage to system or other components
D-24.04.05P	select replacement components	equivalent replacement components (OEM replacement when mandated) are selected
D-24.04.06P	install replacement components	replacement components are installed according to manufacturers' specifications
D-24.04.07P	conduct tests of ***three-phase motors*** after repair	***three-phase motor*** assembly is tested after repair, connected and functions according to specifications and application
D-24.04.08P	***clean, lubricate and adjust*** components	three-phase motor components are ***cleaned, lubricated, and adjusted*** according to manufacturers' specifications to restore to optimal conditions
D-24.04.09P	record ***tests*** in maintenance schedule	operational problems and ***test*** results are documented in maintenance schedule data
D-24.04.10P	compare and analyze maintenance test results	maintenance is performed according to test results and specifications

Range of variables

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

cleaning, lubrication and adjustment procedures include: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches

field assessments include: sensory inspections, technical inspections

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

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

tests include: vibration, insulation, current, rotation, alignment, voltage

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.04.01L	demonstrate knowledge of ***three-phase motors***, ***three-phase motor components***, their characteristics, applications and operation	identify types of ***three-phase motors***, and describe their characteristics, applications and operation
		identify ***three-phase motor components***, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***three-phase motors***
		interpret information pertaining to ***three-phase motors*** found on drawings and specifications

		explain construction and operating principles of ***three-phase motors***
		interpret information contained on three-phase motor nameplates
D-24.04.02L	demonstrate knowledge of procedures to service and maintain ***three-phase motors*** and ***three-phase motor components***	identify tools and equipment used to service and maintain ***three-phase motors*** and ***three-phase motor components***, and describe their applications and procedures for use
		describe procedures to service ***three-phase motors*** and ***three-phase motor components***
		describe procedures to maintain, repair and test ***three-phase motors*** and ***three-phase motor components***

Range of variables

three-phase motors include: squirrel cage induction, wound rotor induction, synchronous
three-phase motor components include: frame, rotor, stator, end bells, fans, brushes, bearings, bushings, slip rings

D-24.05 Installs DC motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.05.01P	determine type of ***DC motor*** required	***DC motor*** to be installed is determined according to ***criteria for operation***
D-24.05.02P	select tools and equipment	tools and equipment are selected according to task
D-24.05.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to CEC requirements
D-24.05.04P	determine and install overload and overcurrent devices	overload and overcurrent devices are installed according to requirements such that motor is protected
D-24.05.05P	position and mount ***DC motor***	***DC motor*** is positioned and mounted according to application
D-24.05.06P	terminate motor leads	motor leads are terminated according to application

D-24.05.07P	conduct tests of ***DC motor*** after installation and record results	***DC motor*** is tested after installation, connected and functions according to manufacturers' and client specifications, and results documented
D-24.05.08P	remove existing ***DC motors*** when replacing and update documentation	existing ***DC motors*** are removed with minimal impact to environment and drawings reflect operational changes

Range of variables

DC motors include: self-excited, separately excited, series, shunt, compound
criteria for operation includes: voltage availability, motor function, rotation, location

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.05.01L	demonstrate knowledge of ***DC motors***, ***DC motor components***, their characteristics, applications and operation	identify types of ***DC motors***, and describe their characteristics, applications and operation
		identify ***DC motor components***, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***DC motors***
		interpret information pertaining to ***DC motors*** found on drawings and specifications
		explain construction and operating principles of ***DC motors***
		interpret information contained on DC motor nameplates
		identify considerations and requirements for selecting ***DC motors,*** controls and ***DC motor components***
D-24.05.02L	demonstrate knowledge of procedures to install and connect ***DC motors*** and ***DC motor components***	identify tools and equipment used to install and connect ***DC motors*** and ***DC motor components***, and describe their applications and procedures for use
		describe procedures to install ***DC motors***, controls and ***DC motor components***
		describe procedures to connect ***DC motors***, controls and ***DC motor components***

Range of variables

DC motors include: self-excited, separately excited, series, shunt, compound
DC motor components include: frame, armature, rotor, stator, commutator, end bells, yoke, fans, brushes, bearings, bushings

D-24.06 Performs servicing and maintenance of DC motors

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-24.06.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
D-24.06.02P	select tools and equipment	tools and equipment are selected according to task
D-24.06.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
D-24.06.04P	identify and remove defective ***DC motor components***	defective ***DC motor components*** are removed without damage to system or other components
D-24.06.05P	select replacement ***DC motor components***	replacement ***DC motor components*** (OEM replacement when mandated) are selected
D-24.06.06P	install replacement ***DC motor components***	replacement ***DC motor components*** are installed according to manufacturers' specifications
D-24.06.07P	conduct tests of DC motors after repair	DC motor assembly is tested after repair, connected and functions according to manufacturers' and client specifications
D-24.06.08P	***clean, lubricate and adjust DC motor components***	***DC motor components*** are ***cleaned, lubricated and adjusted*** according to manufacturers' specifications to restore to optimal conditions
D-24.06.09P	record tests in maintenance schedule	operational problems and test results are documented in maintenance schedule data
D-24.06.10P	compare and analyze maintenance test results	maintenance is performed according to test results and specifications

Range of variables

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

cleaning, lubrication and adjustment procedures include: cleaning cooling fans, adjusting belt tensioners, lubricating bearings and bushings, cleaning switches, cleaning and adjusting brushes, cleaning commutator segments

DC motor components include: frame, armature, field windings, commutator, end bells, yoke, fans, brushes, bearings, bushings

field assessments include: sensory inspections, technical inspections

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

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-24.06.01L	demonstrate knowledge of ***DC motors***, ***DC motor components***, their characteristics, applications and operation	identify types of ***DC motors***, and describe their characteristics, applications and operation
		identify ***DC motor components***, and describe their characteristics and applications
		interpret codes and regulations pertaining to ***DC motors***
		interpret information pertaining to ***DC motors*** found on drawings and specifications
		explain construction and operating principles of ***DC motors***
		interpret information contained on DC motor nameplates
D-24.06.02L	demonstrate knowledge of procedures to service and maintain ***DC motors*** and ***DC motor components***	identify tools and equipment used to service and maintain ***DC motors*** and ***DC motor components***, and describe their applications and procedures for use
		describe procedures to service ***DC motors*** and ***DC motor components***
		describe procedures to maintain ***DC motors*** and ***DC motor components***

Range of variables

DC motors include: self-excited, separately excited, series, shunt, compound

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

Task D-25 Installs, programs, services and maintains automated control systems

Task descriptor

All electrical motors need a method to be started and controlled. These controls can be complex automated systems. Automated control systems are often programmable systems such as Programmable Logic Controller (PLC) and distributed control system (DCS).

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

Construction electricians install and service automated control systems by troubleshooting, diagnosing faults and repairing them. They perform maintenance to ensure automated control systems are in good operating condition. They also program and configure the automated control systems to meet operational requirements.

D-25.01 Installs automated control systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-25.01.01P	determine type of ***automated control system*** required	***automated control system*** is selected according to application and specifications
D-25.01.02P	select tools and equipment	tools and equipment are selected according to task
D-25.01.03P	calculate conductor and cable requirements	conductor and cable type and size are calculated according to application and CEC requirements
D-25.01.04P	position, mount and assemble ***automated control system***	***automated control system*** is placed in locations according to drawings, and job and client requirements; is level, square, and secure, and follows building lines
D-25.01.05P	terminate conductors and cables	conductors and cables are terminated according to drawings, specifications, and AHJ and CEC requirements
D-25.01.06P	bond automated control system to ground	control system is bonded to ground according to code and manufacturers' specifications
D-25.01.07P	set up and adjust ***automated control system***	***automated control system*** operates according to application and intended function
D-25.01.08P	interconnect ***automated control system*** with ***peripheral devices***	***automated control system*** is interconnected with ***peripheral devices*** and equipment functions as intended

D-25.01.09P	conduct tests of automated control system after installation and record results	***automated control system*** is tested after installation, connected and functions according to manufacturers' and client specifications, and results documented
D-25.01.10P	remove existing equipment when replacing and update documentation	existing equipment is removed with minimal impact to environment and drawings reflect operational changes

Range of variables

automated control systems include: PLC, Supervisory Control and Data Acquisition (SCADA) system, DCS

peripheral devices (analog or digital) include: input devices (flow switches, push buttons, limit switches, pressure switches, level switches), output devices (pilot lights, audible devices, relays)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-25.01.01L	demonstrate knowledge of ***automated control systems***, ***automated control system components***, their characteristics, applications and operation	identify types of ***automated control systems***, and describe their characteristics, applications and operation
		identify ***automated control system components***, and describe their applications and operation
		interpret information pertaining to ***automated control systems*** found on drawings and specifications
		interpret codes and regulations pertaining to ***automated control systems***
		identify sources of information pertaining to automated control system service, maintenance, configuration and programming
		identify ***number*** and ***code systems***, and describe their applications
		perform conversions between number systems
		explain and interpret ***control circuit logic***
D-25.01.02L	demonstrate knowledge of ***automated control system data highway systems***, their characteristics, applications and operation	identify types of ***automated control system data highway systems***, and describe their characteristics, applications and operation
		identify automated control system data highway system components, and describe their characteristics, applications and operation
		identify ***methods used to communicate*** with automated control systems

		identify ***basic instruction sets for ladder logic***, and describe their applications
D-25.01.03L	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***

Range of variables

automated control systems include: PLC, SCADA, DCS

automated control system components include: hardware (power supply, central processing unit [CPU], input/output [I/O] system, programming terminals), software

number systems include: binary, decimal, hexadecimal, octal

code systems include: binary coded decimal (BCD), American Standard Code for Information Interchange (ASCII)

control circuit logic includes: relay logic, AND, OR, NOT, NOR, NAND, XOR, MEMORY

automated control system data highway systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet

methods used to communicate with automated control systems include: handheld, computer, human machine interfacing (HMI)

basic instruction sets for ladder logic include: examine if opened (XIO), examine if closed (XIC), output energized (OTE)

D-25.02 Performs servicing maintenance of automated control systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
D-25.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and CPU diagnostics, 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 ***field assessments*** and ***diagnostic and test equipment*** results

D-25.02.04P	identify and remove defective ***automated control system components***	defective ***automated control system components*** are removed without damage to system or other components
D-25.02.05P	repair malfunctioning ***automated control system components*** and verify repair	***automated control system components*** are repaired and tested to ensure they are operational according to manufacturers' specifications
D-25.02.06P	select replacement ***automated control system components***	replacement ***automated control system components*** (OEM replacement when mandated) are selected
D-25.02.07P	install replacement ***automated control system components***	replacement ***automated control system components*** are installed according to manufacturers' specifications
D-25.02.08P	conduct tests of automated control systems after repair	automated control system is tested after repair, connected and functions according to manufacturers' and client specifications
D-25.02.09P	***clean and adjust automated control system components***	automated control systems are restored to optimal conditions
D-25.02.10P	complete backups and record tests in maintenance schedule	operational problems and test results are documented in maintenance schedule data and information is backed up
D-25.02.11P	compare and analyze maintenance test results	maintenance is performed according to test results and specifications

Range of variables

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

cleaning and adjustment procedures include: cleaning fans and filters, adjusting cabinets and door seals

field assessments include: sensory inspections, technical inspections

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

automated control system components include: hardware (power supply, CPU, I/O system, programming terminals), software

	Knowledge	
	Learning Outcomes	**Learning Objectives**
D-25.02.01L	demonstrate knowledge of ***automated control systems, automated control system components***, their characteristics, applications and operation	identify types of ***automated control systems***, and describe their characteristics, applications and operation
		identify ***automated control system components***, and describe their application and operation
		interpret information pertaining to ***automated control systems*** found on drawings and specifications

		interpret codes and regulations pertaining to ***automated control systems***
		identify sources of information pertaining to automated control system service, maintenance, configuration and programming
		identify ***number*** and ***code systems*** and describe their applications
		perform conversions between number systems
		explain and interpret ***control circuit logic***
D-25.02.02L	demonstrate knowledge of ***automated control system data highway systems***, their components, characteristics, applications and operation	identify types of ***automated control system data highway systems***, and describe their characteristics, applications and operation
		identify automated control system data highway system components, and describe their characteristics, applications and operation
		identify ***methods used to communicate*** with automated control systems
		identify ***basic instruction sets for ladder logic***, and describe their applications
D-25.02.03L	demonstrate knowledge of procedures for service and maintenance of ***automated control systems*** and ***automated control system components***	identify tools and equipment used to service and maintain ***automated control systems*** and ***automated control system components***, and describe their applications and procedures for use
		describe procedures to service and maintain ***automated control systems***, and ***automated control system components***

Range of variables

automated control systems include: PLC, SCADA, DCS

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

control circuit logic includes: relay logic, AND, OR, NOT, NOR, NAND, XOR, MEMORY

automated control system data highway systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet

methods used to communicate include: handheld, computer, HMI

basic instruction sets for ladder logic include: XIO, XIC, OTE

D-25.03 Programs and configures automated control systems

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

Skills

	Performance Criteria	Evidence of Attainment
D-25.03.01P	set inputs and outputs, and create I/O tables	inputs and outputs are set, and I/O tables include all required parameters
D-25.03.02P	set names for variables	all variables are named according to client naming application
D-25.03.03P	write and verify automated control program	automated control program operates according to specified logic
D-25.03.04P	set parameters for automated control program	technical and operating parameters are set according to installation and operation
D-25.03.05P	test and adjust automated control program	operation of system meets design

Knowledge

	Learning Outcomes	Learning Objectives
D-25.03.01L	demonstrate knowledge of ***automated control systems***, their characteristics, applications and operation	identify automated control system ***programming languages***, and describe their applications
		explain difference between PLC and DCS systems
		identify types of ***automated control system data highway systems***, and describe their characteristics, applications and operation
D-25.03.02L	demonstrate knowledge of procedures for programming and configuring ***automated control systems***	describe procedures to perform programming, editing and configuration of ***automated control systems*** (online and offline)
		interpret codes and regulations pertaining to ***automated control systems***
		identify ***basic instruction sets for ladder logic*** and describe their applications
		identify ***number*** and ***code systems***, and describe their applications
		perform conversions between ***number systems***
		explain and interpret ***control circuit logic***

Range of variables

automated control systems include: PLC, SCADA, DCS
number systems include: binary, decimal, hexadecimal, octal
code systems include: BCD, ASCII
control circuit logic includes: relay logic, AND, OR, NOT, NOR, NAND, XOR, MEMORY
automated control system data highway systems include: Ethernet, Modbus, Profibus, BACnet, Fieldbus, DeviceNet
methods used to communicate include: handheld, computer, HMI
basic instruction sets for ladder logic include: XIO, XIC, OTE

Major Work Activity E

Installs, services and maintains signalling and communication systems

Task E-26 Installs, services and maintains signalling systems

Task descriptor

Construction electricians install, upgrade, service 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 circuit, extra-low-voltage circuit, Class 1 or Class 2 circuits.

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

E-26.01 Installs fire alarm systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-26.01.01P	determine type of ***fire alarm system*** required	type of ***fire alarm system*** is determined according to drawings, specifications and AHJ
E-26.01.02P	select tools and equipment	tools and equipment are selected according to task
E-26.01.03P	remove and dispose of existing ***fire alarm system components*** when replacing and update documentation	all existing ***fire alarm system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-26.01.04P	determine ***fire alarm system*** layout	***fire alarm system*** layout is determined according to walkthrough of building to identify and mark interference locations on drawings
E-26.01.05P	select ***fire alarm system components***	***fire alarm system components*** are selected according to drawings, specifications and job requirements

E-26.01.06P	position, mount and assemble ***fire alarm system components***	***fire alarm system components*** are positioned, mounted and assembled in locations according to electrical drawings and AHJ
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 drawings, specifications and job requirements
E-26.01.08P	test ***fire alarm system components***	***fire alarm systems components*** are tested and function according to drawings, specifications and jurisdictional regulations
E-26.01.09P	test conductors for opens and ground continuity	conductors have no opens, and all components are bonded to ground and are clear of obstructions
E-26.01.10P	conduct initial fire alarm system tests	sensory and spot tests are performed, and initial fire alarm system tests are performed according to drawings and specifications
E-26.01.11P	participate in startup, commissioning and verification	verification is conducted on ***fire alarm systems***, ***fire alarm system components*** and ***associated systems*** according to regulatory standards, and devices function as intended

Range of variables

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

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), signalling devices (horns, strobes, bells), panels (fire alarm panels [stand-by batteries], annunciator panels), relays

associated systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, local fire department, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-26.01.01L	demonstrate knowledge of ***fire alarm systems***, ***fire alarm system components***, their characteristics, applications and operation	interpret ***codes and regulations*** pertaining to ***fire alarm systems***
		interpret information pertaining to ***fire alarm systems*** found on drawings and specifications

		identify types of ***fire alarm systems***, and describe their characteristics, applications and operation
		identify and describe types of ***associated systems*** that are interconnected with ***fire alarm systems***
		identify ***fire alarm system components***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***fire alarm systems***, and ***fire alarm system components***
E-26.01.02L	demonstrate knowledge of procedures to install, upgrade and connect ***fire alarm systems*** and ***fire alarm system components***	identify tools and equipment used to install, upgrade and connect ***fire alarm systems*** and ***fire alarm system components***, and describe their applications and procedures for use
		describe procedures to install, upgrade and connect ***fire alarm systems*** and ***fire alarm system components***
		describe procedures for testing ***fire alarm systems*** and ***fire alarm system components***
		describe procedures for commissioning and verification of ***fire alarm systems***

Range of variables

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

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

associated systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, local fire department, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans)

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), signalling devices (horns, strobes, bells), panels (fire alarm panels [stand- by batteries], annunciator panels), relays

E 26.02 Performs servicing and maintenance of fire alarm systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-26.02.01P	obtain detailed description of operation and malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and CPU diagnostics, and documented
E-26.02.02P	select tools and equipment	tools and equipment are selected according to task
E-26.02.03P	determine source of malfunction	source of malfunction is determined according to ***field assessments*** and ***diagnostic and test equipment*** results
E-26.02.04P	identify existing ***fire alarm system*** and ***fire alarm system components***	existing ***fire alarm system*** and ***fire alarm system components*** are identified according to as-built drawings, maintenance log and site visit
E-26.02.05P	test ***fire alarm system***	tests are performed according to maintenance schedule; sensory inspections and technical inspections are performed using ***diagnostic and test equipment***
E-26.02.06P	analyze test results	test results are analyzed by comparing manufacturers' certification report and communication log, and according to client requirements
E-26.02.07P	participate in periodic inspections	***fire alarm system, fire alarm system component*** and ***associated systems*** function according to manufacturers' specifications, and are inspected according to maintenance schedule
E-26.02.08P	replace ***fire alarm system components***	***fire alarm system components*** are replaced, tested and verified
E-26.02.09P	update ***documentation*** to reflect servicing, testing, inspections or maintenance performed	***documentation*** is clear, detailed and includes systems and components tested, test results and changes that were completed according to codes, standards and regulations

Range of variables

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

fire alarm systems include: addressable (DCLA, DCLB, DCLC) and non-addressable

(Class A, Class B) systems (single-stage/single-zone, multi-zone, two-stage)

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), 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 systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, local fire department, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems, ancillary devices (suppression system contactors and fans)

documentation includes: maintenance logs, inspection reports, as-built drawings, panel schedules

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

	describe procedures to service and maintain ***fire alarm systems*** and ***fire alarm system components***
	describe procedures for testing ***fire alarm systems*** and ***fire alarm system components***

Range of variables

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

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

fire alarm system components include: end of line devices (resistors, diodes), initiating devices (heat sensors, pull stations, fire/flame detectors, flow switches, gate valve switch, monitoring modules, smoke detectors, tamper switches), signalling devices (horns, strobes, bells), panels (fire alarm panels [stand- by batteries], annunciator panels), relays

associated systems include: fire suppression systems, emergency power supplies fan shutdown/startup, PA systems, local fire department, magnetic door holders, elevator homing contactors, egress door securing and releasing devices, building automation systems

E-26.03 Installs security and surveillance systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-26.03.01P	determine type of ***security and surveillance system*** required	type of ***security and surveillance system*** is determined according to 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 components*** when replacing and update documentation	***security and surveillance system components*** are removed and disposed of in an environmentally conscious manner, and documentation updated
E-26.03.04P	determine ***security and surveillance system*** layout	***security and surveillance system*** layout is determined according to architectural and client requirements
E-26.03.05P	select ***security and surveillance system components***	***security and surveillance system components*** are selected according to drawings, specifications, and job and client 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 drawings, specifications, and job and client requirements
E-26.03.07P	terminate and interconnect ***security and surveillance system components*** and ***associated systems***	***security and surveillance system components*** and ***associated system*** devices are terminated and interconnected according to 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 job and client requirements, and manufacturers' specifications
E-26.03.09P	test ***security and surveillance components*** to ensure functionality	continuity and polarity of video data wiring is tested using ***diagnostic equipment***, and ***security and surveillance system components*** function as required
E-26.03.10P	test conductors for opens and ground continuity	conductors have no opens and all components are bonded to ground and are clear of obstructions
E-26.03.11P	conduct initial security and surveillance system tests	sensory and spot tests are performed; and security and surveillance system tests are performed according to drawings and specifications
E-26.03.12P	participate in startup and commissioning inspections	devices are activated to trigger ***events*** and ***associated systems'*** responses

Range of variables

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, digital video recorders (DVR), motion sensors, card readers, bio-scanners, voice recognitions, electronic locks, horns, panels, proximity sensors, glass break sensors, pressure sensors, radio frequency identification (RFID) tags, key pads, power supplies, servers, graphical user interfaces (GUI)

associated systems include: central alarm monitoring, automatic doors, LAN, building automation systems

diagnostic equipment includes: multimeters, cable analyzers

events include: system surveillance logs, notifications, alarms

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-26.03.01L	demonstrate knowledge of ***security and surveillance systems***, ***security and surveillance system components***, ***associated systems***, 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
		identify and 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 commissioning and verification of ***security and surveillance systems***

Range of variables

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, 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

E-26.04 Performs servicing and maintenance of security and surveillance systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-26.04.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user 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;*** walkthrough is conducted
E-26.04.04P	program and configure ***security and surveillance system***	***security and surveillance system*** is programmed and configured according to job and client requirements
E-26.04.05P	conduct ***security and surveillance*** system tests	tests are performed according to sensory inspections and technical inspections using ***diagnostic equipment and software***
E-26.04.06P	analyze test results	test results are compared to security and surveillance log and client requirements
E-26.04.07P	replace defective ***security and surveillance system components***	replacement ***security and surveillance system components*** are tested and verified
E-26.04.08P	clean and adjust ***security and surveillance system components***	***security and surveillance system component*** functionality (sensors and recording devices cover required area) is restored to optimal conditions
E-26.04.09P	update ***documentation*** to reflect servicing, testing, inspections or maintenance performed	***documentation*** is clear and detailed, and includes ***security and surveillance systems*** and ***security and surveillance system components*** tested and changed, and test and certification results
E-26.04.10P	notify and explain system changes to system monitor	system changes are explained to system monitor

Range of variables

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

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognition, 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

documentation includes: maintenance logs, as-builts

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-26.04.01L	demonstrate knowledge of ***security and surveillance systems***, ***security and surveillance system components***, ***associated systems***, 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
		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 often interconnect with ***security and surveillance systems***
E-26.04.02L	demonstrate knowledge of procedures to service and maintain ***security and surveillance systems*** and ***security and surveillance system components***	identify tools and equipment used to service and maintain ***security and surveillance systems*** and ***security and surveillance system components***, and describe their applications and procedures for use
		describe possible effects of service and maintenance of ***security and surveillance system*** on ***associated systems***
		describe procedures to service and 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 conductors
	describe procedures for commissioning and verification of ***security and surveillance systems***

Range of variables

security and surveillance systems include: perimeter, space, spot

security and surveillance system components include: cameras, monitors, DVRs, motion sensors, card readers, bio-scanners, voice recognitions, 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

Task E-27 Installs, services and maintains communication systems

Task descriptor

Communication systems allow information to be transmitted from one point to another, using different media such as fiber optic, copper and coaxial cables. These types of systems may include low-voltage power circuit, extra-low-voltage power circuit or low-energy power circuit. They include voice/data/video (VDV), community antenna television (CATV), public address (PA), intercom and nurse call systems.

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

Construction electricians service communication systems by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure communication systems are in good operating condition.

E-27.01 Installs voice/data/video (VDV) and community antenna television (CATV) systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-27.01.01P	determine ***VDV and CATV system*** required	type of ***VDV and CATV system*** is determined according to electrical and communication drawings and specifications, job and client requirements, and codes and standards
E-27.01.02P	select tools and equipment	tools and equipment are selected according to task
E-27.01.03P	remove and dispose of existing ***VDV and CATV system components*** when replacing, and update documentation	***VDV and CATV system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-27.01.04P	determine ***VDV and CATV system*** layout	***VDV and CATV system*** layout is determined according to electrical and communication drawings and specifications, client requirements and site visit
E-27.01.05P	select **VDV *and CATV* system *components***	**VDV *and CATV* system *components*** are selected according to electrical and communication drawings and specifications, building material finishes, drawings, and job and client requirements

E-27.01.06P	position, mount and assemble ***communication cabling raceway***	***communication cabling raceway*** is positioned, mounted and assembled according to manufacturers' specifications, industry standards and CEC requirements
E-27.01.07P	temporarily label and install cabling	cabling is labeled and installed according to manufacturers' specifications and CEC requirements
E-27.01.08P	position, mount and assemble **VDV and CATV *system components***	***VDV and CATV system components*** are positioned, mounted, assembled, bonded and functional according to drawings and specifications, CEC, job and client requirements, and codes and standards
E-27.01.09P	terminate and interconnect **VDV and CATV *system components*** and ***associated systems***	***VDV*** **and CATV *components*** and ***associated system*** devices are terminated and interconnected according to ***standards***, electrical and communication drawings and specifications, and job requirements
E-27.01.10P	test and label **VDV and CATV *system components***	cable performance is verified to be within acceptable parameters using ***diagnostic and test equipment*** for system
E-27.01.11P	update documentation for manufacturer certification	as-builts are updated and documentation to support certification is completed

Range of variables

VDV and CATV systems include: unshielded twisted pair (UTP), screened twisted pair (ScTP), category (3, 5e, 6 and 6A), fiber optic, multi-mode and single-mode, coaxial, distributed antenna system (wireless)

VDV and CATV system components include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection devices, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware

communication cabling raceway includes: cable trays, conduits, utility columns, finger rack/ducts, perimeter raceways, wire baskets

associated systems include: telecommunication bonding systems, telephone systems, data systems, security and surveillance systems

standards include: ANSI/TIA-568, 569, 606 and 607, Society of Cabling Telecommunications Engineers (SCTE) for CATV, Building Industry Consulting Services International (BICSI)

diagnostic and test equipment for systems include: Coaxial and CATV (time-domain reflectometers [TDRs]), UTP/ScTP systems (optical time-domain reflectometers [OTDRs], cable analyzers), fiber optic systems (light source power meters, wire map testers, CATV cable analyzers)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-27.01.01L	demonstrate knowledge of ***VDV and CATV systems***, **VDV and CATV *system components***, ***associated systems***, their characteristics, applications and operation	interpret codes and ***standards*** pertaining to ***VDV and CATV systems***
		identify types of ***VDV and CATV systems***, and describe their characteristics, applications, and operation
		identify ***VDV and CATV system components***, and describe their characteristics and applications
		describe types of ***associated systems*** that often interconnect with ***VDV and CATV systems***
		identify considerations and requirements for selecting ***VDV and CATV systems*** and **VDV and CATV *system components***
E-27.01.02L	demonstrate knowledge of procedures to install ***VDV and CATV systems***	identify tools and equipment used to install ***VDV and CATV systems***, and describe their applications and procedures for use
		describe procedures to install ***VDV and CATV systems*** and **VDV and CATV *system components***
		describe procedures for testing ***VDV and CATV systems*** and **VDV and CATV *system components***
		describe procedures for verification and certification of ***VDV and CATV systems***

Range of variables

VDV and CATV systems include*:* UTP, ScTP, category (3, 5e, 6 and 6A), fiber optic, multi-mode and single-mode, coaxial, distributed antenna system (wireless)

standards include: ANSI/TIA-568, 569, 606 and 607, SCTE for CATV, BICSI

VDV and CATV system components include: cabling, termination blocks, outlet jacks, patch panels, face plates, patch cables, cable supports, cable management devices, surge protection devices, connectors, splice trays, cabinets, racks, power supplies, broadcast transmitters, receiving equipment, noise suppressors, satellite dishes, amplifiers, splitters, attenuators, terminators, bonding hardware

associated systems include: telecommunication bonding systems, telephone systems, data systems, security and surveillance systems

E-27.02 Installs public address (PA) and intercom systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-27.02.01P	determine type of ***PA and intercom system*** required	type of ***PA and intercom system*** is determined according to drawings, specifications, and job and client requirements
E-27.02.02P	select tools and equipment	tools and equipment are selected according to task
E-27.02.03P	remove and dispose of existing ***PA and intercom system components*** when replacing and update documentation	***PA and intercom system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-27.02.04P	determine ***PA and intercom system*** layout	***PA and intercom system*** layout is determined according to drawings, job and client requirements, and site visit
E-27.02.05P	select ***PA and intercom system components***	***PA and intercom system components*** are selected according to drawings, specifications, and job and client requirements
E-27.02.06P	position, mount and assemble ***PA and intercom system components***	***PA and intercom system components*** are positioned, mounted and assembled in locations according to drawings, specifications, and job and client requirements
E-27.02.07P	terminate and interconnect ***PA and intercom system components*** and ***associated systems***	***PA and intercom system components*** and ***associated system*** devices are terminated and interconnected according to drawings, specifications and job requirements
E-27.02.08P	test conductors and ***PA and intercom system components*** to ensure functionality	continuity and speaker wiring tests are performed using ***diagnostic and test equipment***, and ***PA and intercom system components*** function as required
E-27.02.09P	test conductors for opens and ground continuity	conductors are tested and have no opens, and all components are bonded to ground and are clear of obstructions

E-27.02.10P	conduct initial ***PA and intercom system*** tests	***PA and intercom system*** tests are performed according to drawings and specifications; and sensory and spot tests are performed
E-27.02.11P	participate in startup, commissioning, inspections and verifications	devices are activated to trigger ***events*** and ***associated systems*** response

Range of variables

PA systems include: wired, wireless

intercom systems include: one-to-one

PA and intercom system components include: microphones, speakers, amplifiers, bells, power supplies, tone generators, receivers

intercom components include: call panels, unit panels, microphones, speakers, tone generators, handsets, door release strikes, GUIs, shielded conductors

associated systems include: fire alarm systems, audio systems, telephone systems, security and surveillance systems

diagnostic and test equipment includes: multimeters, ohmmeters, volt meters

events include: notifications, alarms

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-27.02.01L	demonstrate knowledge of ***PA and intercom systems***, ***PA and intercom system components***, ***associated systems***, their characteristics, applications and operation	interpret codes and regulations pertaining to ***PA and intercom systems***
		interpret information pertaining to ***PA and intercom systems*** found on drawings and specifications
		identify types of ***PA and intercom systems***, and describe their characteristics, applications and operation
		describe types of ***associated systems*** that interconnect with ***PA and intercom systems***
		identify ***PA and intercom system components***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***PA and intercom systems*** and ***PA and intercom system components***
E-27.02.02L	demonstrate knowledge of procedures to install, upgrade and connect ***PA and intercom systems*** and ***PA and intercom system components***	identify tools and equipment used to install, upgrade and connect ***PA and intercom systems*** and ***PA and intercom system components***, and describe their applications and procedures for use

	describe procedures to install, upgrade and connect ***PA and intercom systems***, and ***PA and intercom system components***
	describe procedures for testing ***PA and intercom systems, PA and intercom system components*** and conductors

Range of variables

PA systems include: perimeter, space

intercom systems include: one-to-one

associated systems include: fire alarm systems, audio systems, telephone systems, security and surveillance systems

PA and intercom system components include: microphones, speakers, amplifiers, bells, power supplies, tone generators, receivers

intercom components include: call panels, unit panels, microphones, speakers, tone generators, handsets, door release strikes, GUIs, shielded conductors

E-27.03 Installs nurse call systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-27.03.01P	determine type of ***nurse call system*** required	type of ***nurse call system*** is determined according to drawings, specifications, and job and client requirements
E-27.03.02P	select tools and equipment	tools and equipment are selected according to task
E-27.03.03P	remove and dispose of existing ***nurse call system components*** when replacing and update documentation	***nurse call system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-27.03.04P	determine ***nurse call system*** layout	***nurse call system*** layout is determined according to drawings, client requirements and site visit
E-27.03.05P	select ***nurse call system components***	***nurse call system components*** are selected according to drawings, specifications, and job and client requirements

E-27.03.06P	position, mount and assemble ***nurse call system components***	***nurse call system components*** are positioned, mounted and assembled in locations according to drawings, job and client requirements, and manufacturers' specifications
E-27.03.07P	terminate and interconnect ***nurse call system components*** and ***associated systems***	***nurse call system components*** and ***associated system*** devices are terminated and interconnected according to drawings, specifications and job requirements
E-27.03.08P	test ***nurse call system components*** to ensure functionality	***nurse call system components*** function according to job specifications
E-27.03.09P	test conductors for opens and ground continuity	conductors are tested using ***diagnostic and test equipment*** and have no opens, and all components are grounded and are clear of obstructions
E-27.03.10P	conduct initial ***nurse call system*** tests	***nurse call system*** tests are performed according to drawings and specifications and all devices are tested
E-27.03.11P	label annunciation panels and devices	initiating device and annunciating devices are labelled for identification and servicing
E-27.03.12P	participate in startup and commissioning inspections	devices are activated to trigger events, and ***associated system*** responses

Range of variables

nurse call systems include: one-way, two-way, audible and visual, direct wire, internet protocol (IP) based/structured cabling

nurse call system components include: cameras, monitors, RFID tags, annunciators, panels, key pads, GUIs, power supplies

associated systems include: patient care LAN, emergency power supplies, security and surveillance systems

diagnostic and test equipment include: multimeters, cable analyzers

events include: notifications, alarms

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-27.03.01L	demonstrate knowledge of ***nurse call systems***, ***nurse call system components***, ***associated systems***, their characteristics, applications and operation	interpret codes and regulations pertaining to ***nurse call systems***
		interpret information pertaining to ***nurse call systems*** found on drawings and specifications
		identify types of ***nurse call systems***, and describe their characteristics, applications and operation

		describe types of ***associated systems*** that often interconnect with ***nurse call systems***
		identify ***nurse call system components***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***nurse call systems*** and ***nurse call system components***
E-27.03.02L	demonstrate knowledge of procedures to install ***nurse call systems*** and ***nurse call system components***	identify tools and equipment used to install ***nurse call systems*** and ***nurse call system components***, and describe their applications and procedures for use
		describe procedures to install ***nurse call systems*** and ***nurse call system components***
		describe procedures for testing ***nurse call systems***, ***nurse call system components*** and conductors
		describe procedures for commissioning and verification of ***nurse call systems***

Range of variables

nurse call systems include: one-way, two-way, audible and visual, direct wire, IP-based/structured cabling

associated systems include: patient care LAN, emergency power supplies, security and surveillance systems

nurse call system components include: cameras, monitors, RFID tags, annunciators, panels, key pads, GUIs, power supplies

E-27.04 Performs servicing and maintenance of communication systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-27.04.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
E-27.04.02P	select tools and equipment	tools and equipment are selected according to task

E-27.04.03P	identify existing ***communication system*** and ***communication system components***	existing ***communication system*** and ***communication system components*** are identified according to as-built drawings, maintenance log and certification report, and walkthrough is performed
E-27.04.04P	test ***communication system***	tests are performed according to ***field assessments*** using ***diagnostic and test equipment***
E-27.04.05P	analyze test results	test results are compared to relevant ***documents*** and client requirements
E-27.04.06P	replace ***communication system components***	timing of replacement is scheduled with client; unintentional disruption of system is avoided; replacement ***communication system components*** are tested and verified
E-27.04.07P	update documentation to reflect servicing, testing, inspections or maintenance performed	documentation is clear and detailed, and includes ***communications systems*** and ***communications system components*** tested and changed, and certification results
E-27.04.08P	notify and explain system changes to client	client is informed of system changes

Range of variables

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

communications systems include: VDV and CATV systems (UTP, ScTP, category [3, 5e, 6 and 6A], fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [wireless]), PA systems (perimeter and space), intercom systems (one-to-one), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling)

communications system components include: VDV and CATV system components (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), PA system components (microphones, speakers, amplifiers, bells, power supplies, tone generators, receivers), intercom components (call panels, unit panels, microphones, speakers, tone generators, handsets, door release strikes, GUIs, shielded conductors), nurse call system components (cameras, monitors, RFID tags, annunciator, panels, key pads, power supplies)

field assessments include: sensory inspections, technical inspections

diagnostic and test equipment includes: VDV and CATV systems (TDRs, OTDRs, cable analyzers, light source power meters, wire map testers and CATV cable analyzers), PA systems (multimeters, ohmmeters), nurse call systems (multimeters, cable analyzers)

documents include: manufacturers' certification report, communication log

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-27.04.01L	demonstrate knowledge of ***communication systems***, ***communication system components***, ***associated systems***, their characteristics, applications and operation	interpret codes, standards and regulations pertaining to ***communication systems***
		interpret information pertaining to ***communication systems*** found on drawings and specifications
		identify types of ***communication systems***, and describe their characteristics, applications and operation
		identify ***communication system components***, and describe their characteristics and applications
		describe types of ***associated systems*** that interconnect with ***communication systems***
E-27.04.02L	demonstrate knowledge of procedures to service and maintain ***communication systems*** and ***communication system components***	identify tools and equipment used to service and maintain ***communication systems*** and ***communication system components***, and describe their applications and procedures for use
		describe possible effects of service and maintenance of ***communication system*** on ***associated systems***
		describe procedures to service and maintain ***communication systems***, and ***communication system components***
		describe procedures for testing ***communication systems, communication system components*** and conductors
		describe procedures for verification of ***communication systems***

Range of variables

communications systems include: VDV and CATV systems (UTP, ScTP, category [3, 5e, 6 and 6A], fiber optic, multi-mode and single-mode, coaxial and distributed antenna system [wireless]), PA systems (perimeter and space), intercom systems (one-to-one), nurse call systems (one-way, two-way, audible and visual, direct wire, IP based/structured cabling)

communications system components include: VDV and CATV system components (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), PA system components (microphones, speakers, amplifiers, bells, power supplies, tone generators, receivers), intercom components (call panels, unit panels, microphones, speakers, tone generators, handsets, door release strikes, GUIs, shielded conductors), nurse call system components (cameras, monitors, RFID tags, annunciator, panels, key pads, power supplies)

associated systems include: for VDV and CATV systems (telecommunication bonding systems, telephone systems, data systems, security and surveillance systems), for PA systems (fire alarm systems, audio systems, telephone systems, security and surveillance systems), for nurse call systems (patient care LAN, emergency power supplies, security and surveillance systems)

Task E-28 Installs, services and maintains integrated control systems

Task descriptor

Integrated control systems and building automation systems involve connecting building components through a computerized system in order to achieve automated control over systems such as HVAC, lighting and security systems.

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

Construction electricians service integrated control systems and building automation systems by troubleshooting, diagnosing faults and repairing them. They also perform maintenance to ensure integrated control systems and building automation systems are in good operating condition.

E-28.01 Installs building automation systems

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

	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 and specifications, and job and client specifications
E-28.01.02P	select tools and equipment	tools and equipment are selected according to task
E-28.01.03P	remove and dispose of existing ***building automation system components*** when replacing and update documentation	***building automation system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-28.01.04P	determine ***building automation system*** layout	***building automation system*** layout is determined according to architectural, electrical, communication and mechanical drawings and specifications, job and client requirements, and site visit
E-28.01.05P	select ***building automation system components***	***building automation system components*** are selected according to electrical, communication and mechanical drawings and specifications, and client requirements

E-28.01.06P	position, mount and assemble ***building automation system components***	***building automation system components*** are positioned, mounted and assembled in locations according to architectural, electrical, communication and mechanical drawings and specifications, and job and client requirements
E-28.01.07P	terminate and interconnect ***building automation system components*** and ***associated systems***	***building automation system components*** and ***associated system*** devices are terminated and interconnected according to electrical, communication and mechanical drawings and specifications, and job requirements
E-28.01.08P	test ***building automation system components***	***building automation system components*** are tested and function as required
E-28.01.09P	test conductors for opens and ground continuity	conductors have no opens and all components are bonded to ground and are clear of obstructions
E-28.01.10P	test ***building automation system***	***building automation system*** tests are performed according to specific system being tested
E-28.01.11P	participate in startup and commissioning inspections	devices are activated to trigger functionality of ***building automation system*** and ***associated systems***

Range of variables

building automation systems include: energy management, security and surveillance systems

building automation system components include: network cabling, sensors (occupancy, light levels), servers, Power over Ethernet (PoE) switches, GUIs

associated systems include: building control systems, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-28.01.01L	demonstrate knowledge of ***building automation systems***, ***building automation system components***, ***associated systems***, their characteristics, applications, operation and interconnection	interpret standards pertaining to ***building automation systems***
		interpret information pertaining to ***building automation systems*** found on drawings and specifications
		identify types of ***building automation systems***, and describe their characteristics, applications, operation and interconnection

		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 ***building automation systems*** and ***building automation system components***
E-28.01.02L	demonstrate knowledge of procedures to install ***building automation systems*** and ***building automation system components***	identify tools and equipment used to install ***building automation systems*** and ***building automation system components***, 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***

Range of variables

building automation systems include: energy management, security and surveillance systems

building automation system components include: network cabling, sensors (occupancy, light levels), servers, PoE switches, GUIs

associated systems include: building control system, LAN, elevator systems, fire alarm and suppression systems, security and surveillance systems

E-28.02 Installs building control systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-28.02.01P	determine type of ***building control system*** required	type of ***building control system*** is determined according to electrical and mechanical drawings and specifications, and job and client specifications
E-28.02.02P	select tools and equipment	tools and equipment are selected according to task

E-28.02.03P	remove and dispose of existing ***building control system components*** when replacing and update documentation	***building control system components*** are removed and disposed of according to local codes and waste disposal requirements, and documentation updated
E-28.02.04P	determine ***building control system*** layout	***building control system*** layout is determined according to electrical and communication drawings and specifications, client requirements and site visit
E-28.02.05P	select ***building control system components***	***building control system components*** are selected according to electrical and mechanical drawings and specifications, and job and client requirements
E-28.02.06P	position, mount and assemble ***building control system components***	***building control system components*** are positioned, mounted and assembled in locations according to drawings, specifications, and job and client requirements
E-28.02.07P	terminate and interconnect ***building control system components*** and ***associated systems***	***building control system components*** and ***associated system*** devices are terminated and interconnected according to drawings, specifications, and job requirements
E-28.02.08P	test ***building control system components***	***building control system components*** are tested to ensure functionality
E-28.02.09P	test conductors for opens and ground continuity	conductors are tested using ***diagnostic and test equipment***, have no opens and all components are bonded to ground and are clear of obstructions
E-28.02.10P	test ***building control system***	***building control system*** tests are performed according to drawings, specifications, and functionality tests
E-28.02.11P	participate in startup and commissioning inspections	devices are activated to trigger functionality of ***building control system*** and ***associated systems***

Range of variables

building control systems include: pneumatic, analog electrical and direct digital control (DDC), computer control

building control system components include: damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, sensors (humidity, digital, analog, pressure differential, temperature, light level, occupancy, level/float)

associated systems include: building automation systems, HVAC, lighting, security and surveillance systems

diagnostic and test equipment includes: multimeters

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-28.02.01L	demonstrate knowledge of ***building control systems***, ***building control system components***, ***associated systems***, their characteristics, applications and operation	interpret ***standards*** pertaining to ***building control systems***
		interpret information pertaining to ***building control systems*** found on drawings and specifications
		identify types of ***building control systems***, and describe their characteristics, applications and operation
		identify ***building control system components***, and describe their characteristics and applications
		describe types of ***associated systems*** that interconnect with ***building control systems***
		identify considerations and requirements for selecting ***building control systems***, and ***building control system components***
E-28.02.02L	demonstrate knowledge of procedures to install ***building control systems*** and ***building control system components***	identify tools and equipment used to install ***building control systems*** and ***building control system components***, and describe their applications and procedures for use
		describe procedures to install ***building control systems*** and ***building control system components***
		describe procedures for testing ***building control systems***, ***building control system components*** and conductors
		describe procedures for commissioning and verification of ***building control systems***

Range of variables

building control systems include: pneumatic, analog electrical and DDC, computer control

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

building control system components include: damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, sensors (humidity, digital, analog, pressure differential, temperature, light level, occupancy, level/float)

associated systems include: building automation systems, HVAC, lighting, security and surveillance systems

E-28.03 Performs servicing and maintenance of integrated control systems

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

	Skills	
	Performance Criteria	**Evidence of Attainment**
E-28.03.01P	obtain detailed description of malfunction	detailed description of operation, malfunction issues and ***information*** are obtained from end user and documented
E-28.03.02P	select tools and equipment	tools and equipment are selected according to task
E-28.03.03P	identify ***integrated control system*** and ***integrated control system components***	***integrated control system*** and ***integrated control system components*** are identified according to as-built drawings, maintenance log and site visit
E-28.03.04P	test ***integrated control system***	***integrated control system*** is tested and system activation performed
E-28.03.05P	analyze test results	test results are compared to manufacturers' certification report, communication log and client requirements
E-28.03.06P	adjust ***integrated control system components***	***integrated control system components*** are adjusted
E-28.03.07P	replace ***integrated control system components***	replacement is scheduled with client and local monitoring station and replacement ***integrated control system components*** are tested and verified
E-28.03.08P	update documentation to reflect servicing, testing, inspections and maintenance performed	***documentation*** is clear and detailed, and includes ***integrated control systems*** and ***integrated control system components*** tested and changed, and test and certification results
E-28.03.09P	notify and explain system changes to system operator	system changes are explained to system operator

Range of variables

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

integrated control systems include: HVAC controls, lighting controls, energy management, elevator systems, fire alarm and fire suppression systems, security and surveillance systems

integrated control system components include: damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, sensors (humidity, digital, analog, pressure differential, temperature, light level, occupancy, level/float)

	Knowledge	
	Learning Outcomes	**Learning Objectives**
E-28.03.01L	demonstrate knowledge of ***integrated control systems***, ***integrated control system components***, ***associated systems***, their characteristics, applications and operation	interpret ***standards*** pertaining to integrated control systems
		interpret information pertaining to ***integrated control systems*** found on drawings and specifications
		identify types of ***integrated control systems***, and describe their characteristics, applications and operation
		identify ***integrated control system components***, and describe their characteristics and applications
		identify considerations and requirements for selecting ***integrated control systems*** and ***integrated control system components***
		describe types of ***associated systems*** that interconnect with ***integrated control systems***
E-28.03.02L	demonstrate knowledge of procedures to service and maintain ***integrated control systems*** and ***integrated control system components***	identify tools and equipment used to service and maintain ***integrated control systems*** and ***integrated control system components***, and describe their applications and procedures for use
		describe possible effects of service and maintenance of ***integrated control systems*** on ***associated systems***
		describe procedures to service and maintain ***integrated control systems*** and ***integrated control system components***
		describe procedures for testing ***integrated control systems***, ***integrated control system components*** and conductors
		describe procedures for commissioning and verification of ***integrated control systems***

Range of variables

integrated control systems include: HVAC controls, lighting controls, energy management, elevator systems, fire alarm and fire suppression systems, security and surveillance systems

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

integrated control system components include: damper motors, valves, contactors, contacts, annunciators, thermostats, solenoids, flow and sail switches, sensors (humidity, digital, analog, pressure differential, temperature, light level, occupancy, level/float)

associated systems include: building automation systems, HVAC, lighting, security and surveillance systems

Appendix A Acronyms

AC	alternating current
AFCI	arc fault circuit interrupter
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ARCAL	aircraft radio control of aerodrome lighting
AVR	Automatic Voltage Regulator
ASCII	American Standard Code for Information Interchange
BAC	Building Automation and Control
AR	augmented reality
BCD	binary coded decimal
BD	block diagram
BICSI	Building Industry Consulting Services International
CAD	computer-aided design
CATV	community antenna television
CCR	constant current regulator
CEC	Canadian Electrical Code
CCTV	closed circuit television
CO^2	carbon dioxide
CPU	central processing unit
CSA	Canadian Standards Association
CSC	Construction Specifications Canada
CT	current transformers
DC	direct current
DCS	distributed control system
DDC	direct digital control
DVR	digital video recorder
EMC	electro-magnetic compatibility
EMI	electro-magnetic interference
EV	electric vehicles
FLA	full load amps
FLC	full load current
FMP	Fault Managed Power
GFCI	ground fault circuit interrupter
GPS	global positioning system
GUI	graphical user interface
HMI	human machine interfacing
HVAC	heating, ventilation and air-conditioning
I/O	input/output

IEEE	Institute of Electrical and Electronics Engineers
IL	instruction list
IP	Internet Protocol
kVA	kilovolt-amps
LAN	local area network
LD	ladder diagram
LEED	Leadership in Energy and Environmental Design
MCC	motor control centre
MOV	metal oxide varistor
MSDS	material safety data sheets
NBC	National Building Code
NEMA	National Electrical Manufacturers' Association
NETA	North American Electrical Testing Association
NFC	National Fire Code
O&M	operations and maintenance
OEM	original equipment manufacturer
OH&S	Occupational Health and Safety
OTDR	optical time-domain reflectometer
OTE	output energized
PA	public address
PDC	power distribution centre
PLC	programmable logic controller
PoE	power over Ethernet
PPE	personal protective equipment
PQA	Power Quality Analyzer
VTs	voltage transformers
RFID	radio frequency identification
SCADA	Supervisory Control and Data Acquisition
SCTE	Society of Cabling Telecommunications Engineers
ScTP	screened twisted pair
SPL	sound pressure level
SFC	sequential function chart
SSL	solid-state lighting
ST	structured test
TDR	time-domain reflectometer
TIA	Telecommunications Industry Association
ULC	Underwriters Laboratories of Canada
UTP	unshielded twisted pair
VDV	voice / data / video
VFD	variable frequency drive
VR	virtual reality

WHMIS	Workplace Hazardous Materials Information System
WLL	working load limit
XIO	examine if opened
XIC	examine if closed

Appendix B
Tools and Equipment / Outils et équipement

Standard Tools / Outils courants

adjustable wrenches	clés à molette
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
cameras	caméras
centre punches	pointeaux à centrer
chalk lines	cordeaux
coaxial strippers and crimpers	outils à dénuder les câbles coaxiaux et sertisseuses de câbles coaxiaux
cold chisels	ciseaux à froid
combination squares	équerres combinées
combination wrench sets	jeux de clés mixtes
crimping pliers	pinces à sertir
crowbars	pieds-de-biche
diagonal cutting pliers	pinces à coupe diagonale
drill bits (auger, masonary, step and wood)	forets (hélicoïdaux, de maçonnerie, étagés et à bois)
files	limes
fish tapes	rubans de tirage
flashlights	lampes de poche
fuse pullers	arrache-fusibles
hack saws	scies à métaux
hammers (ball peen, dead blow and rubber)	marteaux (à panne ronde, à amortisseur et en caoutchouc)
hex key sets (metric/imperial)	jeux de clés hexagonales (métriques et impériales)
hole saws	scies passe-partout
hot sticks	perches isolantes
knives	couteaux
knockout punch sets	jeux de poinçons emporte-pièces
levels including torpedo	niveaux (y compris les niveaux à torpille)
lineman pliers	pinces d'électricien

measuring tapes	rubans à mesurer
needle nose pliers	pinces à bec effilé
nipple chucks	mandrins à mamelons
nut drivers (metric/imperial)	tournevis à douille (métriques et impériaux)
pipe benders	plieuses à tuyaux
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
plumb bobs	fils à plomb
screw starters	pose-vis
screwdrivers – Robertson, Phillips, torx, flat, tamper-proof	tournevis (à pointe carrée, cruciformes, Torx, plats et inviolables)
scribes	pointes à tracer
side/diagonal cutters	pinces à coupe latérale ou diagonale
slip joint pliers	pinces à axe coulissant
socket sets (metric/imperial)	jeux de douilles (métriques et impérales)
spline keys	clavettes
speed wrenches	clés à vilebrequin
tap and die sets (metric/imperial)	jeux de tarauds à fileter et de filières (métriques et impériaux)
tin snips	cisailles de ferblantier
tool belts	ceintures à outils
tool buckets	seaux à outils
triple taps	fileteuses triples
trouble lights	lampes baladeuses
vises	étaux
vice grip pliers	pinces-étaux
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
wire strippers	pinces à dénuder les fils
wood chisels	ciseaux à bois
wood saws	scies à bois
wrenches (metric/imperial)	clés (métriques et impériales)

Personal Protective Equipment (PPE) and Safety Equipment / Équipement de protection individuelle et équipement de sécurité

anchor slings (cable and nylon)	élingues d'ancrage (à câble et en nylon)
PPE for arc flash equipment	équipement de protection individuelle contre les arcs électriques
barricades	barrières
breaker locks (multi-lock, lock box, lock tag)	dispositifs de cadenassage de disjoncteur (cadenas multiples, boîtiers de sécurité et étiquettes cadenas)
carabiners	mousquetons
dust masks	masques antipoussières
confined space equipment	équipement pour espace clos
coveralls (fire retardant)	combinaisons (ignifuges)
ear plugs and muffs	bouche-oreilles et casques antibruits
emergency eyewash equipment	douches oculaires d'urgence
face shields	écrans faciaux
fall arresters equipment	dispositifs antichutes
fall restraint equipment	dispositifs de retenue en cas de chute
fire blankets	couvertures anti-feu
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
gloves	gants
goggles	lunettes à coque
grounding straps	bracelets de mise à la terre
grounding sticks	perches de mise à la terre
hard hats	casques de sécurité
harnesses (full body)	harnais (complets)
high visibility vests	gilets de haute visibilité
high-voltage gloves (insulated)	gants de protection contre la haute tension (isolés)
high-voltage test equipment	appareils de vérification haute tension
hot pads	tapis isolants
hot sticks	perches isolantes
insulated gloves	gants isolants
knee pads	genouillères
lanyards (energy absorbing and twin leg)	longes de sécurité (amortisseuses et doubles)
life lines	cordes de sécurité

lock-out kits	trousses de cadenassage
low-voltage gloves (insulated)	gants de protection contre la basse tension (isolés)
portable GFCIs	disjoncteurs différentiels portatifs
portable lights	baladeuses
protective gloves/gauntlets	gants et gantelets de protection
pylons	cônes de signalisation
respirators	appareils respiratoires
restraint devices	dispositifs de retenue
rope grabs	coulisseaux de sécurité
safety belts (travel restraint)	ceintures de sécurité (limitation du déplacement)
safety footwear	bottes de sécurité
safety glasses	lunettes de sécurité
safety harnesses	harnais de sécurité
safety vests	gilets de sécurité
self-contained breathing apparatus	appareils respiratoires autonomes
self-retracting lifelines	câbles de sécurité autorétractables
signage	panneaux d'avertissement
temporary protective ground equipment	conducteurs de mise à la terre de protection temporaire
ventilation equipment	équipement de ventilation
warning tape	ruban d'avertissement
welding gloves	gants de soudeur
welding helmets/masks	casques et masques de soudeur

Access Equipment / Appareils et dispositifs d'accès

aerial work platforms (AWPs)	nacelles élévatrices
articulated boom lifts	nacelles articulées
boom lifts	élévateurs à nacelle
construction elevators	ascenseurs de chantier
ladders (extension, fixed, step)	échelles (à perches, fixes) et escabeaux
lift tables	tables élévatrices
man baskets	descendeurs à nacelle
scaffolds (rolling, mechanical, stationary, ladder jack)	échafaudages (roulants, mécaniques, fixes, sur échelles)
scissor lifts	plateformes élévatrices à ciseaux
swing stages	échafaudages volants

Power Tools and Equipment / Outils et équipement mécaniques

band saws	scies à ruban
battery/rechargeable drills	perceuses à pile rechargeable
bench grinders	meuleuses d'établi
cable pullers	tire-câbles
chop saws	tronçonneuses
circular saws	scies circulaire
core drills	carotteuses
drill presses	perceuses à colonne
grinders	meuleuses
hammer drills	marteaux perforateurs
heat guns	pistolets à air chaud
hole saw kits	ensembles de scies-cloches
jig saws	scies sauteuses
knock-out punches (powered)	emporte-pièces mécaniques
magnetic drills	perceuses magnétiques
pneumatic hammer drills	marteaux perforateurs pneumatiques
power cable feeders	artères pour câbles d'alimentation
power crimpers	sertisseurs mécaniques
power drills	perceuses mécaniques
power pipe benders	plieuses à tuyaux mécaniques
power pipe cutters	coupe-tuyaux mécaniques
power pipe threaders	machines à fileter les tuyaux
power pullers	tracteurs de tire
power reel lifts	dispositifs de levage des bobines
PVC benders	plieuses à tuyaux en PVC
reciprocating saws	scies alternative
sump pumps	pompes de puisard
vacuums	aspirateurs

Specialty Tools and Equipment / Outils et équipement spécialisés

chain falls	palans à chaîne
come-alongs	pince-câbles
communication devices (cellphones and 2-way radio)	dispositifs de communication (téléphones cellulaires, radios avec émetteur-récepteur)
creepers and crawlers	robots chenillés
extension cords	rallonges électriques
grip hoists	palans à machoire
hot sticks	perches isolantes
inverters	onduleurs
laser levels	niveaux à laser
manual hoists	treuils manuels
picks	pioches
pneumatic hoists	palans pneumatiques
portable generators	génératrices portatives
powder actuated tools	outils à charge explosive
reel jacks	vérins de touret
ropes	cordes
shackles	manilles
shovels	pelles
sledgehammers	masses
slings	élingues
soldering apparatus	appareils de brasage tendre
spud wrenches	clés à mâchoires
strain relief grips	réducteurs de tension
thermit (thermal) welders	soudeuses aluminothermiques
torque wrenches	clés dynamométriques
wire racks	étagères grillagées

Measuring Equipment / Appareils de mesure

ammeters	ampèremètres
cable locators	détecteurs de câbles
clamp ammeters	pinces ampèremétriques
fault locators	localisateurs de défauts
frequency meters	fréquencemètres
ground megohmmeters	mégohmmètres de résistance de terre
high pot testers (dielectric tester)	vérificateurs de rigidité diélectrique
inductive voltage detectors	détecteurs de tension par induction
insulation resistance testers	vérificateurs de résistance d'isolement
jumpers	bretelles
LAN meters (cable analysers)	vérificateurs de réseaux locaux (analyseurs de câbles)
light meters	luxmètres
megohmmeters (insulation testers)	mégohmmètres (vérificateurs d'isolement)
multimeters	multimètres
ohmmeters	ohmmètres
optical time-domain reflectometers (OTDR)	réflectomètres optiques dans le domaine temporel
oscilloscopes	oscilloscopes
phase/motor rotation meters	indicateurs de rotation de moteur et d'ordre des phases
power quality analyzers	analyseurs de qualité énergétique
recording meters (watts, volts and amps)	instrument de mesure enregistreur (watts, volts, ampères)
tachometers	tachymètres
thermographic imaging devices	thermographes
thermometers (infra-red and electronic)	thermomètres (infra rouges et électroniques)
ultrasonic testing equipment	appareils de tests par ultrasons
voltage testers	vérificateurs de tension
voltmeters	voltmètres
watt meters	wattmètres

Appendix C
Glossary/Glossaire

ancillary	functions performed by the fire alarm system as an output of the fire alarm system, controlled by a relay or similar device, for example, elevator recall, fan shut down and door release	**auxiliaire**	qualifie les fonctions que le système d'alarme d'incendie exécute en tant que sortie du système d'alarme d'incendie commandée par un relais ou un dispositif semblable, par exemple, un dispositif de rappel d'ascenseur, un interrupteur d'arrêt de ventilateur et un bouton d'ouverture de porte.
bonding	a 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.
cathodic 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 faisant de cette surface la cathode d'une cellule électrochimique.
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	a 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 system	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-energy power circuit	a circuit where the power is limited to 100 VA where V is the open circuit voltage	**circuit d'alimentation à faible énergie**	circuit dont l'alimentation se limite à 100 VA, où V est la tension du circuit ouvert
low-voltage system	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 the 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.
luminaire	a complete lighting unit designed to accommodate the lamp(s) and to connect the lamp(s) to circuit conductors, for example, florescent, High Intensity Discharge (HID) and incandescent	**luminaire**	appareil d'éclairage complet destiné à recevoir les lampe et à raccorder celles-ci à des conducteurs de circuit, par exemple une lampe fluorescente, une lampe à haute intensité de décharge et une lampe à incandescence

raceway	any channel designed for holding wires, cables or busbars, and, unless otherwise qualified by rules of the CEC, the term includes conduit (rigid, flexible, metal, non-metallic) electrical metallic and non-metallic tubing, underfloor raceway, 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.
specifications	an explicit set of requirements to be satisfied by a material, product or service including but not limited to local and national building codes, any documentation that holds legal obligations, schematics, manufacturers' specifications, local code, provincial/federal authority, engineered drawings and diagrams and schematics, client requirements, warranty documents, site drawings, shop drawings, company requirements	**spécifications**	ensemble précis de conditions auxquelles un matériau, un produit ou un service doit satisfaire, y compris sans s'y limiter, les codes nationaux et locaux du bâtiment, tout document qui détient des obligations légales, les schémas, les spécifications des fabricants, les codes locaux, les autorités fédérales et provinciales, les dessins, les diagrammes et les schémas techniques, les exigences des clients, les documents reliés à la garantie, les dessins de chantier et d'atelier et les exigences des entreprises