UNIT 1

General Information for Electrical Installations

OBJECTIVES

After studying this unit, the student will able to

- explain how electrical wiring information is conveyed to the electrician at the construction or installation site.
- demonstrate how the specifications are used in estimating cost and in making electrical installations.
- identify and explain the application of the various common line types used on drawings.
- explain why symbols and notations are used on electrical drawings.
- list the agencies that are responsible for establishing electrical standards and ensuring that materials meet the standards.
- discuss the metric system of measurement.
- begin to refer to the *Canadian Electrical Code, Part I.*

THE WORKING DRAWINGS

The architect or engineer uses a set of working drawings or plans to make the necessary instructions available to the skilled trades that are to build the structure shown in the plans. The sizes, quantities, and locations of the materials required and the construction features of the structural members are shown at a glance. These details of construction must be studied and interpreted by each skilled construction trade—masons, carpenters, electricians, and others—before the actual work is started.

The electrician must be able to: (1) convert the two-dimensional plans into an actual electrical installation, and (2) visualize the many different views of the plans and coordinate them into a three-dimensional picture, as shown in Fig. 1–1 on page 2.

The ability to visualize an accurate three-dimensional picture requires a thorough knowledge of blueprint reading. Since all of the skilled trades use a common set of plans, the electrician must be able to interpret the lines and symbols that refer to the electrical installation and also those used by the other construction trades. The electrician must know the structural makeup of the building and the construction materials to be used.

SPECIFICATIONS

Working drawings are usually complex because of the amount of information that must be included. To prevent confusing detail, it is standard practice to include with each set of plans a set of detailed written specifications prepared by the architect.

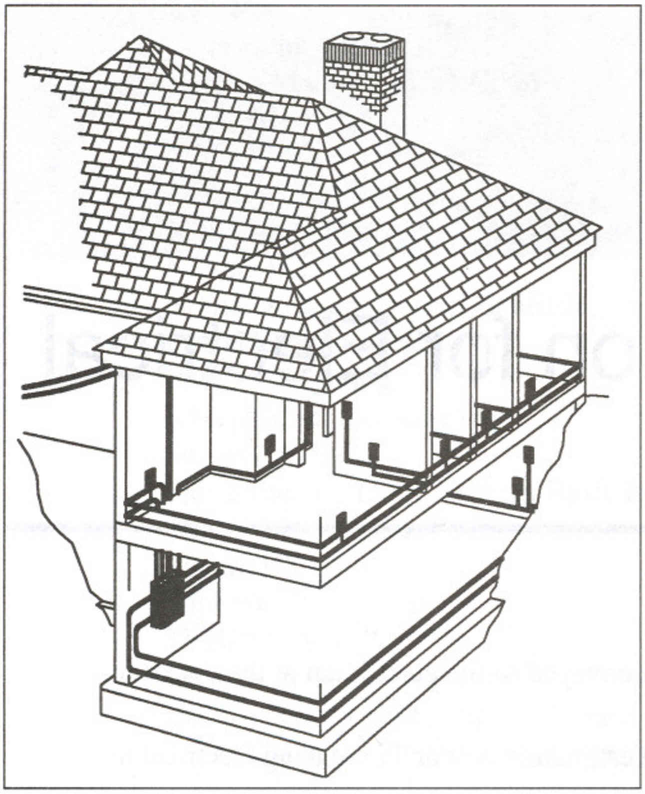


Fig. 1–1 Three-dimensional view of house wiring.

These specifications provide general information to be used by all trades involved in the construction. In addition, specialized information is given for the individual trades. The specifications include information on the sizes, type, and desired quality of the standard parts to be used in the structure.

Typical specifications include a section on "General Clauses and Conditions" that is applicable to all trades involved in the construction. This section is followed by detailed requirements for the various trades—excavating, masonry, carpentry, plumbing, heating, electrical, painting, and others.

The plan drawings for the residence used as an example for this text are included in the back of the text. The specifications for the electrical work indicated on the plans are given in the Appendix.

In the electrical specifications, the list of standard electrical parts and supplies frequently includes the manufacturers' names and the catalogue numbers of the specified items. Such information ensures that these items will be of the correct size, type, and electrical rating, and that the quality will meet a certain standard. To allow for the possibility that the contractor will not always be able to obtain the specified item, the phrase "or equivalent" is usually added after the manufacturer's name and catalogue number.

The specifications are also useful to the electrical contractor in that all of the items needed for a specific job are grouped together and the type or size of each item is indicated. This information allows the contractor to prepare an accurate cost estimate without having to find all of the data in the plans.

LINES, SYMBOLS, AND NOTATIONS

The purpose of a drawing is to show the size and shape of an object. Lines, symbols and notations are used to convey information about the drawing to the viewer. Each of the various line types used in the drawing have a specific meaning. The line types listed below are named for the function they perform or the portion of the drawing they represent.

Visible lines Visible lines are continuous lines which show the visible edges of an object. An example of a visible line would be the outside edge of the foundation wall shown on sheet 5 of the drawings.

Hidden lines Hidden lines are short dashed lines. They are used to show the edges of an object that are hidden from view by surfaces which are closer to the viewer. Hidden lines are used to show the building footings on sheet 2 of the drawings.

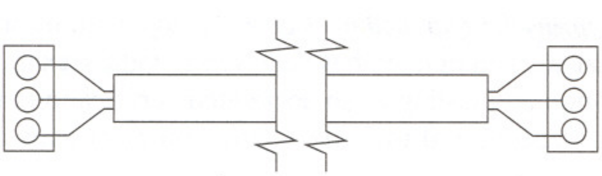
Centre lines Centre lines are used to show the center of an arc or circle. They consist of alternating long and short dashes. The exact centre of a circle is normally indicated by the crossing of the two short dashes.

Section lines A sectional view (also referred to as a section or cross-section) is a view of a building in which we imagine a portion of the building has been sliced off to reveal the internal construction details. Section lines show the solid parts (walls, floors, etc.) of the portion of the building shown in the sectional view. Section lines are also referred to as crosshatching. Different types of crosshatching represent different types of materials used in the building. In Section A-A on sheet 7 of the drawings, different types of crosshatching indicate concrete used for the basement floor, cement blocks used for the basement walls, and bricks used on the outside walls above grade.

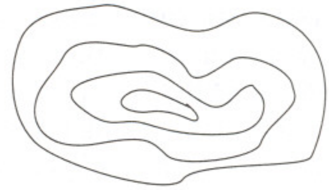
Cutting plane lines Cutting plane lines consist of a long dash followed by two short dashes. They are used on drawings to indicate where a building is being sectioned. The basement floor plan, sheet 1 of the drawings, uses a cutting plane line to show where the building is being sectioned. The arrows at each end of a cutting plane line indicate the direction you are looking when you are viewing the section. Refer to section A-A on sheet 7.

Phantom lines Phantom lines are short dashed lines (about 1-1/2 times as long as the dashes for hidden lines) that are used to show an alternate position. The diagram on page 184 shows two, single-pole double-throw (SPDT) switches. There are two closed switch positions on a SPDT switch. The first closed position is shown by the solid line and the second closed position is shown by the phantom line.

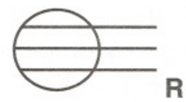
Break lines Break lines are used where only a part of the drawing needs to be shown. For example, a break line might be used in a connection diagram where it is necessary to show the termination of both ends of a cable but not the cable in between.



Contour lines Contour lines are used on plot plans to show changes in elevation. Dashed contour lines indicate existing grades and solid contour lines show finished grades.



The architect uses symbols and notations to simplify the drawing and presentation of information concerning electrical devices, appliances, and equipment. For example, an electric range outlet looks like this:



Most symbols have a standard interpretation throughout the country, as adopted by the Canadian Standards Association's *Standard Z99.3-1979(R1989).* Symbols are described in detail in Unit 2.

A notation will generally be found on the plans (blueprints) next to a specific symbol calling attention to a variation, type, size, quantity, or other necessary information. In reality, a symbol might be considered to be a notation because, according to the dictionary, symbols "represent words, phrases, numbers, and quantities".

Another method of using notations to avoid cluttering up a blueprint is to provide a system of symbols that refer to a specific table. For example, the written sentences on plans could be included in a table referred to by a notation. Fig. 2–9 (page 18) is an example of how this could be done. The special symbols that refer to the table would have been shown on the actual plan.

CANADIAN ELECTRICAL CODE, PART I (C.E.C., PART I)

Because of the ever-present shock hazard or danger of fire through some failure of the electrical system, the electrician and the electrical contractor must use approved materials and perform all work in accordance with recognized standards. The *Canadian*

Electrical Code, Part I is the basic standard that governs electrical work. Its purpose is to provide information considered necessary for safeguarding people and property against electrical hazards. It states: "Compliance with the requirements of this code and proper maintenance will ensure an essentially safe installation." *Section 0—Object, Scope and Definitions.* (*Note:* All *C.E.C., Part I* section references used throughout this text are printed in italics.) It is the electrician's responsibility to ensure that the installation meets these criteria. In addition to the *C.E.C., Part I,* the electrician must also consider local and provincial codes. The object and scope are discussed in *Section O* of the *C.E.C., Part I* and should be studied by the student at this time.

The first edition of the *Canadian Electrical Code* was published in 1927. It is revised and updated every four years by changing, editing, and adding technical material, sections, articles, tables, and so on, so as to be as up to date as possible relative to electrical installations. For example, the *C.E.C., Part 1* added *Section 86* to address issues applicable to electric vehicle charging systems. There is also a major revision to Section 18, Hazardous Locations, to reflect the European system of identification.

As materials, equipment, and technologies change, the members of the CEC Committee solicit comments and proposals from individuals in the electrical industry and from others interested in electrical safety. The committee members meet every six months to deal with proposals from the 42 section subcommittees regarding changes to the *Canadian Electrical Code*. These are voted on and the final draft is prepared for publication as the *Canadian Electrical Code, Part I.*

The CEC Committee consists of individuals representing over 50 organizations, including the International Association of Electrical Inspectors, the Institute of Electrical and Electronic Engineers, the Canadian Electrical Contractors Association, the *National Electrical Code®* (U.S.), the Underwriters' Laboratories of Canada, the Canadian Standards Association, the International Brotherhood of Electrical Workers, and many others.

Copies of the *Canadian Electrical Code, Part I* may be ordered from

Canadian Standards Association
178 Rexdale Boulevard
Etobicoke, ON M9W 1R3

Code Definitions

The electrical industry uses many words (terms) that are unique to the electrical trade. These terms need clear definitions to enable the electrician to understand completely the meaning intended by the Code.

Section 0 of the *C.E.C., Part I* includes a "dictionary" of these terms. Here are a few of these definitions:

Ampacity: means current-carrying capacity of electrical conductors expressed in amperes.

Acceptable: means acceptable to the authority enforcing this code.

Alive or live: means electrically connected to a source of voltage difference, or electrically charged so as to have a voltage different from that of the earth. The term may also be used in place of "current carrying."

Dwelling unit: means one or more rooms for the use of one or more persons as a housekeeping unit with cooking, eating, living and sleeping facilities. (*Note:* The terms "dwelling" and "residence" are used interchangeably throughout this text.)

Identified: (as applied to a conductor) means

a. a white or natural grey covering;
b. a raised longitudinal ridge or ridges on the surfaceof the extended covering on the conductors of certain flexible cords.

Voltage of a circuit: means the greatest root-mean-square (effective) voltage between any two conductors of the circuit concerned.

Extra-low voltage means any voltage up to and including 30 V.

Low voltage means any voltage from 31 to 750 V inclusive.

High voltage means any voltage above 750 V.

Approved, as applied to electrical equipment: means that such equipment has been submitted for examination and testing to an accredited certification organization and that the equipment conforms to appropriate Canadian Standards Association (CSA) standards.

Notwithstanding: *Rule 8–106(7).* In spite of.

Practicable: feasible, possible. *Rule 6–408(1)(b).*

In the rules of the *C.E.C., Part I*, the word "shall" indicates a mandatory requirement. Examples are as follows:

shall be: compulsory, mandatory, a requirement, must be
shall have: the same as shall be
shall not: not allowed, not permitted to be done, must not be, against the code.
shall be permitted: is allowed, may be done, not against the code.

A very important rule in the *C.E.C., Part I* is *Section 2–024,* which states that all electrical equipment shall be approved and shall be of a type and rating approved for the specific purpose for which it is to be used. This means that electrical equipment must be installed and used in accordance with Canadian Electrical Code and Canadian Standards Association (CSA) standards. If the equipment does not have the proper approval or rating, it may not be installed until CSA approval has been obtained.

For example, equipment imported into Canada must meet with CSA approval before it may be installed. The local hydro inspection authority or the provincial ministry of labour will provide information on how this may be achieved.

CODE USE OF METRIC (SI) MEASUREMENTS

The *C.E.C. Part I* has introduced the use of metric measurements in addition to imperial measurements. The metric system is known as the *International System of Units (SI).*

Metric measurements appear in the *C.E.C., Part I* as follows:

- In the rules, the metric measurement appears with its symbol, as shown in Fig. 1–5, the table of symbols for SI units.
- In the tables, the metric prefix accompanies the measurement, e.g., kcmil.
- References to trade sizes of conduit will reflect the traditional inch trade sizes followed by the "Metric Trade Designation" in parentheses, eg. $\frac{3}{4}$-in (21-mm) trade size
- Usable space and capacity of boxes are indicated in millilitres followed by the cubic inch value in parentheses, or in cubic centimetres. One cubic centimetre is equal to one millilitre.

A metric value is not shown for AWG sizes or motor horsepower ratings.

Guide to Metric Usage

In the metric system, the units increase or decrease in multiples of 10, 100, 1000, and so on. For instance, one megawatt (1 000 000 watts) is 1000 times greater than one kilowatt (1000 watts).

By assigning a name to a measurement, such as a *watt*, the name becomes the unit. Adding a prefix to the unit, such as *kilo*, forms the new name *kilowatt*, meaning 1000 watts. Refer to Fig. 1–2 for prefixes used in the metric system.

mega	1 000 000	(one million)
kilo	1 000	(one thousand)
hecto	100	(one hundred)
deka	10	(ten)
the unit	1	(one)
deci	0.1	(one-tenth) (1/10)
centi	0.01	(one-hundredth) (1/100)
milli	0.001	(one-thousandth) (1/1 000)
micro	0.000 001	(one-millionth) (1/1 000 000)
nano	0.000 000 001	(one-billionth) (1/1 000 000 000)

Fig. 1–2 Metric prefixes and their values.

The prefixes used most commonly are *centi*, *kilo*, and *milli*. Consider that the basic unit is a metre. Therefore, a centimetre is 0.01 metre, a kilometre is 1000 metres, and a millimetre is 0.001 metre.

Some common measurements of length and equivalents are shown in Fig. 1–3.

Electricians will find it useful to refer to the conversion factors and their abbreviations shown in Figs. 1–4 and 1–5.

one inch	=	2.54	centimetres
	=	25.4	millimetres
	=	0.025 4	metre
one foot	=	12	inches
	=	0.304 8	metre
	=	30.48	centimetres
	=	304.8	millimetres
one yard	=	3	feet
	=	36	inches
	=	0.914 4	metre
	=	914.4	millimetres
one metre	=	100	centimetres
	=	1 000	millimetres
	=	1.093	yards
	=	3.281	feet
	=	39.370	inches

Fig. 1–3 Some common measurements of length and their equivalents.

inches (in) x 0.025 4	= metres (m)
inches (in) x 0.254	= decimetres (dm)
inches (in) x 2.54	= centimetres (cm)
centimetres (cm) x 0.393 7	= inches (in)
inches (in) x 25.4	= millimetres (mm)
millimetres (mm) x 0.039 37	= inches (in)
feet (ft) x 0.304 8	= metres (m)
metres (m) x 3.280 8	= feet (ft)
square inches (in^2) x 6.452	= square centimetres (cm^2)
square centimetres (cm^2) x 0.155	= square inches (in^2)
square feet (ft^2) x 0.093	= square metres (m^2)
square metres (m^2) x 10.764	= square feet (ft^2)
square yards (yd^2) x 0.836 1	= square metres (m^2)
square metres (m^2) x 1.196	= square yards (yd^2)
metres (m) x 1 000	= kilometres (km)
kilometres (km) x 0.621	= miles (mi)
miles (mi) x 1.609	= kilometres (km)

Fig. 1–4 Useful conversions (imperial/SI–SI/imperial) and unit abbreviations.

SYMBOLS FOR SI UNITS

Symbol	SI Unit	Multiplying Factor for Conversion to Previously Used Unit	Previously Used Unit
A	ampere(s)	1	ampere(s)
cm^3	cubic centimetre(s)	0.061	cubic inch(es)
°	degree(s) (angle)	1	degree(s) (angle)
°C rise	degree(s) Celsius	1.8	degree(s) Fahrenheit
°C temperature	degree(s) Celsius	1.8 plus 32	degree(s) Fahrenheit
h	hour(s)	1	hour(s) (time)
Hz	hertz	1	cycle(s) per second
J	joule(s)	0.7376	foot-pound(s)
kg	kilogram(s)	2.205	pound(s)
kJ	kilojoule(s)	737.6	foot-pound(s)
km	kilometre(s)	0.621	mile(s)
kPa	kilopascal(s)	0.295	inch(es) of mercury
		0.334	feet of water
		0.145	pound(s) per square inch (psi)
lx	lux	0.093	foot-candle(s)
L	litre	0.229	gallon(s)
m	metre(s)	3.281	feet
m^2	square metre(s)	10.764	square feet
m^3	cubic metre(s)	35.315	cubic feet
MHz	megahertz	1	megacycles per second
min	minute(s)	1	minute(s)
mm	millimetre(s)	0.03937	inch(es)
mm^2	square millimetre(s)	0.00155	square inch(es)
Ω	ohm(s)	1	ohm(s)
Pa	pascal(s)	0.000295	inch(es) of mercury
		0.000334	feet of water
		0.000145	pounds per square inch (psi)
V	volt(s)	1	volt(s)
W	watt(s)	1	watt(s)
μF	microfarad(s)	1	microfarad(s)

Fig. 1–5 ***C.E.C., Part I*** **Symbols for SI units and conversion factors.**

CANADIAN STANDARDS ASSOCIATION (CSA)

The Canadian Standards Association is a nonprofit organization that was formed in 1919 to develop standards for a variety of organizations and disciplines. These standards are the cornerstone for product certification, and are subsequently approved by provincial and federal government authorities to become recognized throughout the country.

Thousands of manufacturers work directly with the CSA on the certification process and the CSA mark appears on many new products every year.

For more information please write to:

Canadian Standards Association
Customer Service Department
178 Rexdale Boulevard
Etobicoke, ON M9W 1R3
Tel: (416) 747–4000
1-800-463-6727
Fax: (416) 747–4149
http: //www.csa.ca

UNDERWRITERS' LABORATORIES OF CANADA (ULC)

Underwriters' Laboratories of Canada is a not-for-profit organization that maintains and operates laboratories and the certification service for testing and classification of devices, constructions, materials, and systems to determine their relation to life, fire, and property hazards.

ULC also publishes standards, specifications, and classifications for products having a bearing on fire, accident, or property hazards.

For more information please write to:

Underwriters' Laboratories of Canada
7 Crouse Road
Scarborough, ON M1R 3A9
Tel: (416) 757–3611
1-800-INFO-ULC
Fax: (416) 757-9540
http: //www.ulc.ca
E-mail: ulcinfo@ulc.ca

STANDARDS COUNCIL OF CANADA (SCC)

The objective of the Standards Council of Canada is to promote efficient and effective voluntary standardization as a means of advancing the national economy, and benefiting the health, safety, and welfare of the public.

The Council fulfills its mandate by accrediting organizations engaged in standard development, certification, testing and quality, and environmental registration. It is also responsible for approving National Standards of Canada (NSC).

The Council represents Canada on international standards bodies or agencies and accredits Canadian technical experts to international standards committees. The Council also offers a comprehensive family of information, products, and services dealing with standards, regulations, and conformity assessment procedures. Through these activities the Council facilitates Canadian and international trade, protects consumers, and promotes international standards cooperation.

For more information please write to:

Standards Council of Canada
1200-45 O'Conner Street
Ottawa, ON K1P 6N7
Tel: (613) 238-3222
http: //www.scc.ca

UNDERWRITERS LABORATORIES INC. (UL)

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Copies of UL publications may be obtained from:

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062
Tel: (847) 272–8800
http: //www.ul.com

ETL Testing Laboratories, Inc. is another nationally recognized testing laboratory. They provide a labelling, listing, and follow-up service for the safety testing of electrical products to nationally recognized safety standards or specifically designated requirements of jurisdictional authorities. Information can be obtained by writing to:

Intertek Testing Services
3933 US Route 11
Cortland, NY 13045
Tel: (607) 758-6439
Fax: (607) 756-9891
http: //www.etl.com

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

The American National Standards Institute is an organization that coordinates the efforts and results of the various standards-developing organizations, such as those mentioned in previous paragraphs. Through this process, ANSI approves standards that then become recognized as American national standards. One will find much similarity between the technical information found in ANSI standards, the Underwriters standards, the International Electronic and Electrical Engineers standards, and the *National Electrical Code®* (U.S.).