Chapter 3

Drawings and Specifications

Topics

1.0.0 Common Terms and Definitions

2.0.0 Construction Drawings

3.0.0 Blueprints

4.0.0 Plans

5.0.0 Specifications

6.0.0 Types of Drawings and Diagrams

To hear audio, click on the box.

Overview

The Naval bases, advance bases, Seabee camps, and equipment of the Navy were all built from plans drawn on blueprints. They are operated, checked, and maintained according to information found on those same blueprints. When the equipment fails in service or is damaged in battle, blueprints aid the repairman. When new parts are to be made or a facility is expanded, blueprints provide the necessary information. Planning, scheduling, and manpower and material estimating are based on the information contained in these blueprints. This chapter discusses the function and care of blueprints and the importance of being able to read and work from them.

This chapter will also discuss electrical diagrams and schematics. Diagrams and schematics are maps that indicate the configuration of circuits and circuit connections and components of electrical equipment. When properly used, they are an invaluable aid in the installation, troubleshooting, and repair of electrical components. Understanding and being able to use blueprints and schematics will be some of the most important work assignments you will have as a Construction Electrician.

Objectives

When you have completed this chapter, you will be able to do the following:

1. Identify definitions and terms associated with drawings and specifications
2. Understand the contents and limitations of construction drawings
3. Understand the use and contents of blueprints
4. Describe the types and contents of plans
5. Describe the different types of specifications utilized
6. Describe the different types of construction drawings and diagram.

Prerequisites

None

This course map shows all of the chapters in Construction Electrician Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.

Test Equipment, Motors, and Controllers	↑	C E
Communications and Lighting Systems		
Interior Wiring and Lighting		
Power Distribution		
Power Generation		
Basic Line Construction/Maintenance Vehicle Operations and Maintenance		B A
Pole Climbing and Rescue		S
Drawings and Specifications		I
Construction Support		C
Basic Electrical Theory and Mathematics		

Features of this Manual

This manual has several features which make it easier to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with an italicized instruction telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to

return to the review question. Try to answer the question again.

1.0.0 COMMON TERMS and DEFINITIONS

To be able to work with, and from, drawings and specifications, you must know the terms commonly associated with planning, estimating, and scheduling. Listed below are few of the terms you will need to do your job.

1.1.0 Definitions

Activity estimates consist of a listing of all the steps required to construct a given project. Activity quantities provide the basis for preparing material, equipment, and manpower estimates. They are used to provide the basis for scheduling, material deliveries, equipment, and manpower.

Bill of material (BM) is a tabulated statement of the material required for a given project. It contains such information as stock numbers, unit of issue, quantity, line-item number, description, vendor, and cost. Sometimes the bill of material will be submitted on either material estimate sheets or material takeoff sheets; the two sheets contain similar information. Usually, the takeoff sheet is an actual tally and checkoff of the items shown, noted, or specified on the construction drawings and specifications.

Construction activities are a breakdown of master activities. They identify functional parts of the project and are often assigned to a particular company (Bravo/Charlie) or rating.

Detailed estimates are precise statements of quantities of material, equipment, and manpower required to construct a given project. Underestimating quantities can cause serious delays in construction or result in unfinished projects. A detailed estimate must be accurate to the smallest detail to quantify requirements correctly.

Direct labor includes all the labor expended directly on assigned construction tasks, in either the field or the shop, that contribute directly to the completion of the end product.

Equipment estimates consist of a listing of the types of equipment, amount of time, and number of pieces required to construct a given project.

Estimating is the process of determining the amount and type of work to be performed and the quantities of material, equipment, and labor required.

Indirect labor includes labor required to support construction operations but which does not, in itself, produce an end product.

Manpower estimates consist of a listing of the number of direct labor man-days required to complete the various activities of a specific project. These estimates may show only the man-days for each activity or they may be in sufficient detail to list the number of man-days for each rating.

Master activities consist of a breakdown of a complete project in sufficient detail to provide a comprehensive description of the project.

Material estimates consist of a listing and description of the various materials and the quantities of those materials required to construct a given project. Information for preparing material estimates is obtained from the activity estimates, drawings, and specifications.

Planning is the process of determining requirements and devising and developing methods and a scheme of action for construction of a project. Good construction planning is a combination of elements: the activity, material, equipment, and manpower estimates: project layout; project location; material delivery and storage; work

schedules; quality control; special tools required; environmental protection: safety; and progress control. All of these elements depend upon each other. They must be taken into account in any well-planned project.

Preliminary estimates are made from limited information, such as the general description of projects or preliminary plans and specifications having little or no detail. Preliminary estimates are prepared to establish costs for the budget and to program general manpower requirements.

Scheduling is the process of determining when an action must be taken and when materials, equipment, and manpower will be required. It shows the sequence, the time for starting, the time required for performance and the time for completion.

Test your Knowledge (Select the Correct Response)

1. The process of determining the amount and type of work to be performed is the definition of which of the following terms?

   A. Scheduling
   B. Preliminary Estimates
   C. Estimating
   D. Material Estimates

2.0.0 CONSTRUCTION DRAWINGS

The basis for defining the required activities, measuring the quantities of material, and making accurate estimates is the information contained in construction drawings. You should read all notes and references carefully and examine all details and reference drawings thoroughly. Check the orientation of sectional views carefully. Verify the revision section near the title block to check whether the indicated changes were in fact made in the drawing itself. When there are inconsistencies between drawings and specifications, the specifications should take precedence.

Drawings are generally categorized according to their intended purposes: preliminary**, presentation, working,** and shop drawings**.**

A building project may be broadly divided into two major phases: the design phase and the construction phase. First, the **preliminary drawings** are prepared during the design phase. They are prepared by the Engineering Field Division (**EFD**) or by an architect's and engineer's (**A/E**) firm. The designer uses preliminary drawings for exploring design concepts with the user (customer), making material selection, getting preliminary cost estimates, and as a basis for preparing the finished working drawings.

The ***presentation drawings*** are developed to show the proposed building or facility in an attractive setting in its natural surroundings at the proposed site. Since these drawings are actually used to sell an idea or a design, you will probably see this type of drawing only as a cover sheet to a set of construction drawings.

In the second phase, after approval has been given for construction, the **working drawings** are developed. ***Shop drawings*** are supplied by manufacturers to show fabrication of building parts. After review by the architect and engineer, they become part of the working drawings. Throughout your career, you will hear working drawings referred to as blueprints, construction drawings, prints, or plans. Basically, these terms are all correct; they can be used interchangeably.

As mentioned earlier, the construction drawings are developed from the preliminary drawings. The EFD and A/E, collaborate to decide both the materials to be used and the

construction methods to be followed. The engineer determines the loads that the supporting structural members will be required to bear and designs the mechanical systems, such as heating, power, lighting, and plumbing.

As a crew member or a supervisor, you will find the construction drawings, specifications, and the bill of material your main sources of information during the construction and estimating phases of the project.

Drawings are commonly indexed so you can easily find the sheet you need. The drawing index is located on the cover sheet or sheet 1 of the set. They are divided into eight categories and appear in the following order:

1. Plot and vicinity
2. Landscape and irrigation
3. Architect
4. Structural
5. Mechanical
6. Plumbing
7. Electrical
8. Fire protection

2.1.0 Working Sketches

A working sketch is a drawing made from the working drawings to clearly express a tasking and to provide a quick reference to job requirements. It is drawn to help show actual conditions on the job, the size of pipe to be installed, or the location of connections to be made. The sketch should show as much detail as possible to help your crew during installation or troubleshooting. A working sketch will usually show the work you want your crew to accomplish in a selected area and will provide ready reference to jobsite conditions.

A crew should have a working sketch with them while working. It will show them how, what, where, and when things happen in the sequence of the job. Your first step in making a working sketch is to draw the symbols representing all the fixtures or equipment to be installed and locating them within the room. Try to draw them in the sequence of installation and to include measurements. The amount of detail you use in a working sketch will be determined by the crew's experience, the complexity of the systems involved, and the need for cooperation with other trades working on the jobsite.

2.2.0 As-Built Drawings

Upon the completion of a facility, the crew leader or project supervisor should provide marked prints that indicate any construction deviations. The information the prints must show is all features of the project as actually built. As-built drawings should be reviewed after they are completed. This review assures that all information appearing on the drawings shows the exact as-built conditions.

From the as-built drawings, record drawings are prepared. These drawings are the original construction drawings corrected according to the as-built marked print. They provide a permanent record of as-built conditions. The final record drawings must be kept up to date at all times. If this maintenance requires a change to the record drawing, then this information should be passed on and the record drawings updated.

2.3.0 Symbols

One of the most important symbols to use right at the beginning of a new job is the directional symbol. This symbol, usually an arrow labeled "N" for north, enables the reader of a construction drawing to orient it. A drawing is properly oriented when it is held so that the north arrow shown on the drawing is pointing toward north. Construction Electricians sometimes find themselves standing in open ground with only a drawing and an area staked off by the Engineering Aid, who tells them where to start shoveling for an underground conduit run. The drawing must be properly oriented so the reader can relate the information on it to the surrounding area. Understanding common standard symbols, such as the north arrow mentioned above, is a must for someone who expects to do well in electrical construction work.

Some of the most common symbols in construction work are listed in *Figure 3-1*. Study these symbols carefully. A good way to memorize them is to copy each symbol several times while thinking of the electrical component or device it represents. Learn to relate each symbol mentally to the component it represents whenever you see the component. For example, as you pull the wire through a conduit in a floor slab, you might try to recall the symbol mentally for "wiring concealed in floor." When you walk into the company office and see a duplex receptacle outlet, you should think about its symbol. This practice will enable you to associate symbols to actual electrical devices. This type of training will help you become a better Construction Electrician.

Although the symbols in *Figure 3-1* are the most common standard symbols, they are by no means the only ones you will see in your work. Sometimes a symbol for a particular component or device may have been created by the architect or engineer who developed the drawing. For various reasons, some of the symbols on a drawing may not be standard. Many times you will figure out what a symbol means by analyzing it and thinking about what it looks like. The legend on a drawing should show any nonstandard symbols and their meanings.

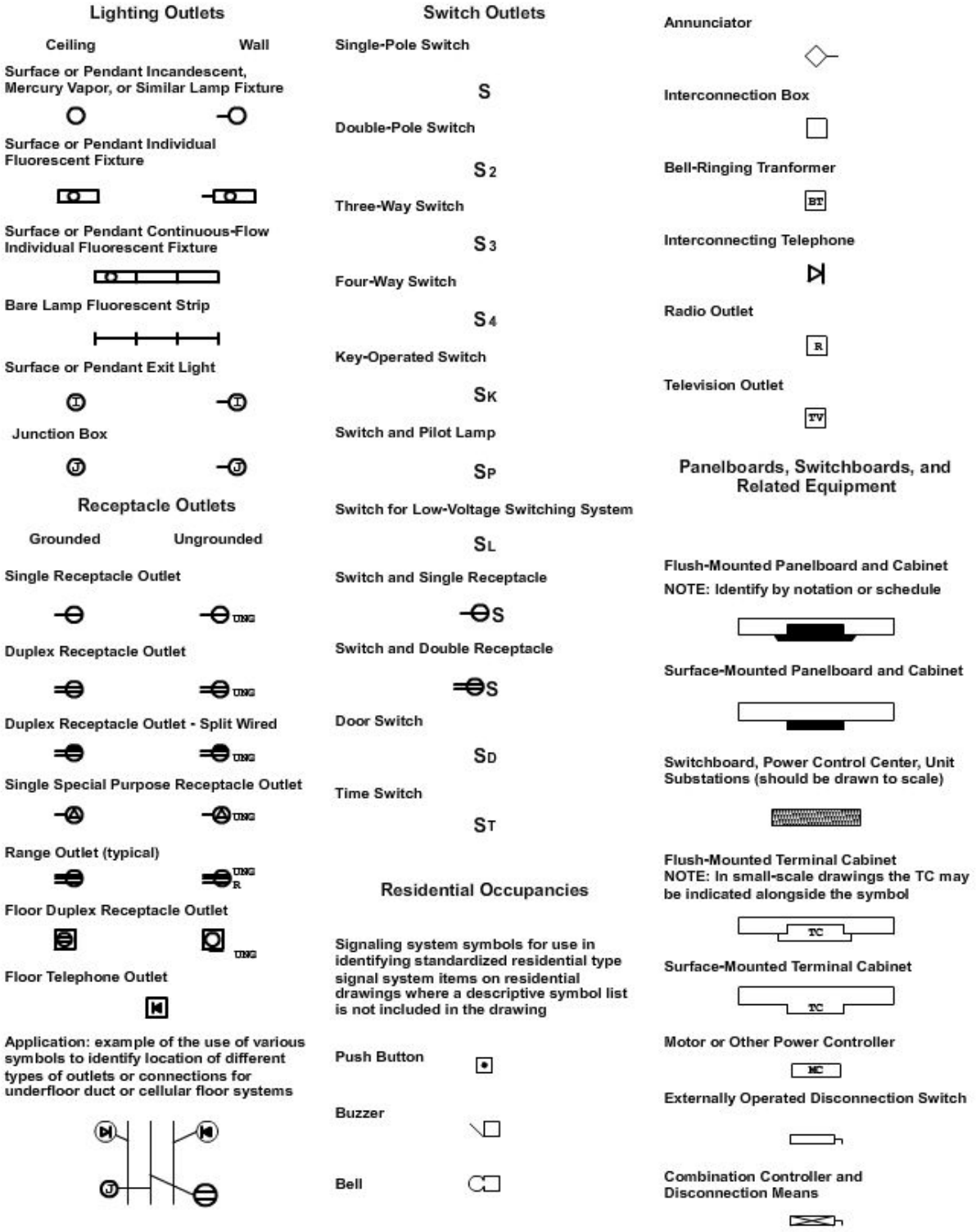


Figure 3-1 – Electrical symbols used in construction.

Remote Control Stations for Motors or Other Equipment

Push-button Stations in General

Float Switch - Mechanical

Limit Switch - Mechanical

Pneumatic Switch - Mechanical

Electric Eye - Beam Source

Electric Eye - Relay

Thermostat

Circuiting

Wiring method identification by notation on drawing or in specifications.

Wiring Concealed in Ceiling or Wall

Note: Use heavy weight line to identify service and feed runs

Wiring Concealed in Floor

Wiring Exposed

Branch Circuit Home Run to Panelboard

Number of arrows indicates number of circuits. (A numeral at each arrow may be used to identify circuit number.)

2 1

NOTE: Any circuit without further identification indicates a 2-wire circuit. For a greater number of wires, indicate with cross lines.

Application:

3 wires;
4 wires; etc

Unless indicated otherwise, the wire size of the circuit is the minimum size required by the specification.
Indicate size in inches and identify different functions of wiring system, such as signaling, by notation or other means.

Wiring Turned Up

Wiring Turned Down

Manhole

Handhole

Transformer Pad

Underground Direct Burial Cable

Indicate type, size, and number of conductors by notation or schedule.

Underground Duct Line

Indicate type, size, and number of ducts by cross section identification of each run by notation or schedule. Indicate type, size, and number of conductors by notation or schedule.

Streetlight Standard Fed from Underground Circuit

Electrical Distribution or Lighting Systems, Aerial

Pole

Pole, with Streetlight

Pole, with Down Guy and Anchor

Transformer

Transformer, Constant-Current

Switch, Manual

Circuit Recloser, Automatic

Circuit, Primary

Circuit, Secondary

Circuit, Series Street Lighting

Down Guy

Head Guy

Sidewalk Guy

Service Weather Head

Figure 3-1 – Electrical Symbols used in construction continued.

Figure 3-2 shows more standard electrical symbols which you may encounter.

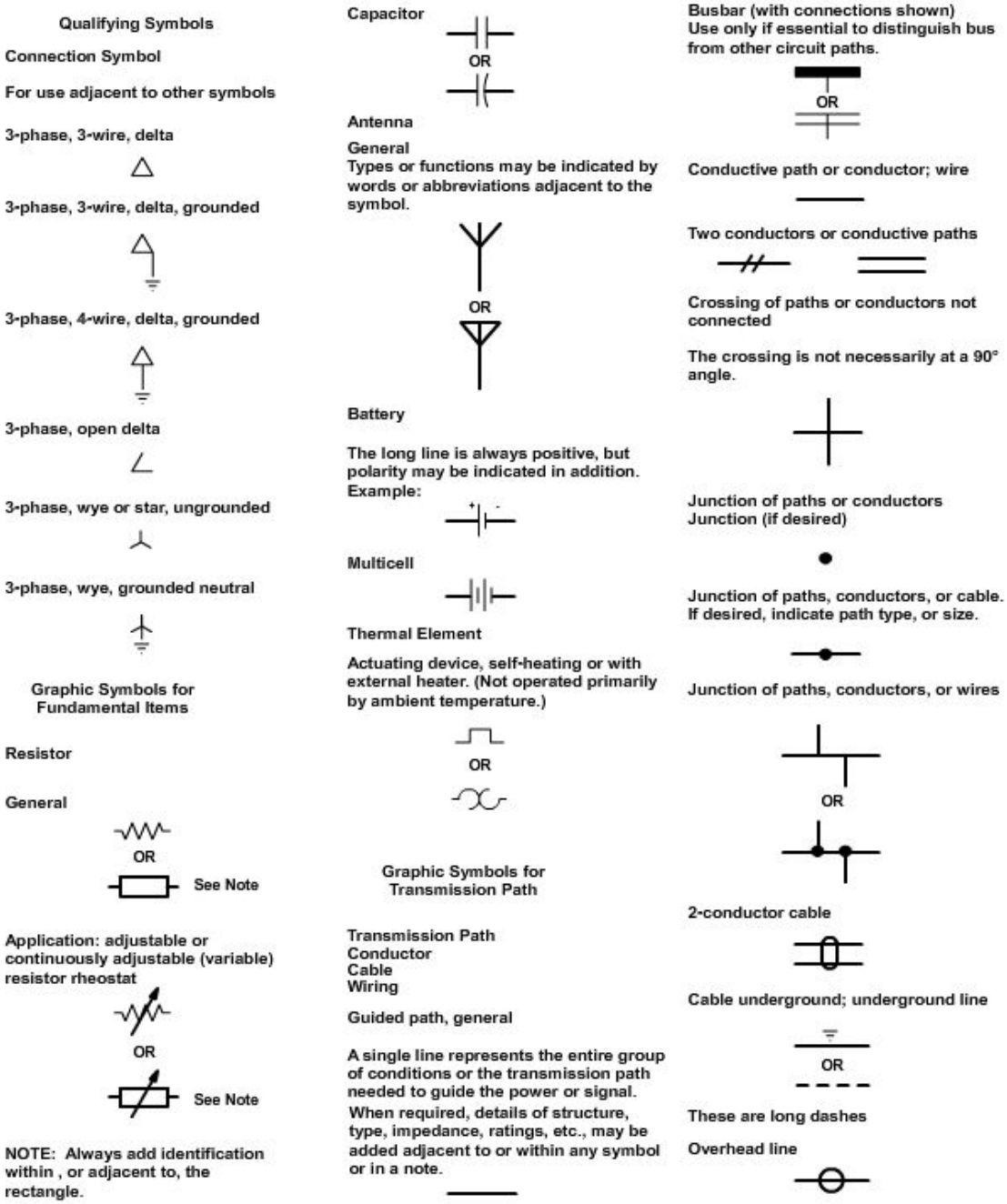


Figure 3-2 – Electrical symbols used in construction.

Circuit Return

Ground general symbol

NOTE: Supplementary information may be added to define the status or purpose of the earth if this is not readily apparent.

(1) A direct conducting connection to the earth or body of water that is a part therof.

(2) A conducting connect to a structure that serves a function similar to that of an earth ground (that is, a structure such as a frame of an air, space, or land vehicle that is not conductively connected to earth).

Chassis or frame connection, equivalent chassis connection (of printed-wiring boards)

A conducting connection to a chassis of frame (or equivalent chassis connection of a printed-wiring board) may be at substantial potential with respect to the earth or structure in which this chassis or frame (or printed-wiring board) is mounted.

Graphic Symbols for Contacts, Switches, Contacts, and Relays

Electrical Contact

Fixed contact for jack, key, relay, switch, etc.

OR

Sleeve

OR

The broken line - - - indicates where line connection to a symbol is made and is not part of the symbol.

Moving Contact

Adjustable or sliding contact for resistor, inductor, etc.

OR

Locking

Nonlocking

Basic Contact Assemblies

The standard method of showing a contact is by a symbol indicating the circuit condition it produces when the actuating device is in the de-energized or nonoperated position. The actuating device may be of a mechanical, electrical, or other nature, and a clarifying note may be necessary with the symbol to explain the proper point at which the contact functions; for example, the point where a contact closes or opens as a function of changing pressure, level, flow, voltage, current, etc. In cases where it is desirable to show contacts in the energized or operated condition and where confusion may result, a clarifying note shall be added to the drawing.

Closed contact (break)

OR

OR

Open contact (make)

OR

OR

Transfer

OR

OR

Make-before-break

Magnetic Blowout Coil

OR

Operating Coil
Relay Coil

OR

OR

OR

* See Note

Switch

Fundamental symbols for contacts, mechanical connections, etc, may be used for switch symbols.

Single-throw, general

Double-throw, general

2-pole double-throw switch with terminals shown

NOTE: The asterisk is not part of the symbol. Always replace the asterisk by a device designation.

Figure 3-2 – Electrical symbols used in construction continued.

Push button, Momentary or Spring-Return

Circuit closing (make)

Circuit opening (break)

Two-circuit

Selector or Multiposition Switch

The position in which the switch is shown may be indicated by a note or designation of switch position.

General (for power and control diagrams)

Any number of transmission paths may be shown.

OR

Limit Switch
Sensitive Switch

NOTE: Identity by LS or other suitable note.

Track-type, circuit-closing contact

Track-type, circuit-opening contact

Flow-Actuated Switch

Closes on increase in flow

Opens on increase in flow

Liquid-Level-Actuated Switch

Closes on rising level

Opens on rising level

Pressure-or Vacuum-Actuated Switch

Closes on rising pressure

Opens on rising pressure

Temperature-Actuated Switch

Closes on rising temperature

Opens on rising temperature

Thermostat

Closes on rising temperature

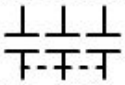
* See Note

Contactor

See also CIRCUIT BREAKER

Fundamental symbols for contacts, coils, mechanical connections, etc, are the basis of contactor symbols and should be used to represent contactors on complete diagrams. Complete diagrams of contactors consist of combinations of fundamental symbols for control coils, mechanical connections, etc, in such configurations as to represent the actual device. Mechanical interlocking should be indicated by notes.

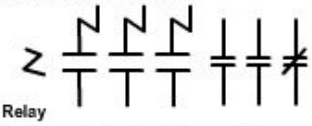
Manually operated 3-pole contactor



NOTE: The t° symbol shall be shown or be replaced by data giving the nominal or specific operating temperature of the device.

Electrically operated 1-pole contactor with series blowout coil

Electrically operated 3-pole contactor with series blowout coils; 2 open and 1 closed auxiliary contacts (shown smaller than the main contacts)



Relay

Fundamental symbols for contacts, mechanical connections, coils, etc, are the basis of relays on complete diagrams.

The following letter combinations or symbol elements may be used with relay symbols. The requisite number of these letters or symbol elements may be used to show what special features a relay possesses.

- AC Alternating-current or ringing relay
- D Differential
- DB Double-biased (biased in both directions)
- DP Dashpot
- EP Electrically polarized
- FO Fast-operate
- FR Fast-release
- L Latching
- MG Marginal
- ML Magnetic-latching (re-manent)
- NB No bias
- NR Nonreactive

- P Magnetically polarized using biasing spring, or having magnet bias
- SA Slow-operate and slow-release

- SO Slow-operate
- SR Slow-release
- SW Sandwich-wound to improve balance to longitudinal currents

The proper poling for a polarized relay shall be shown by the use of + and - designations applied to the winding leads. The interpretation of this shall be that a voltage applied with the polarity as indicated shall cause the armature to move toward the contact shown nearer the coil on the diagram. If the relay is equipped with numbered terminals, the proper terminal numbers shall alson be shown.

Basic

Figure 3-2 – Electrical symbols used in construction continued.

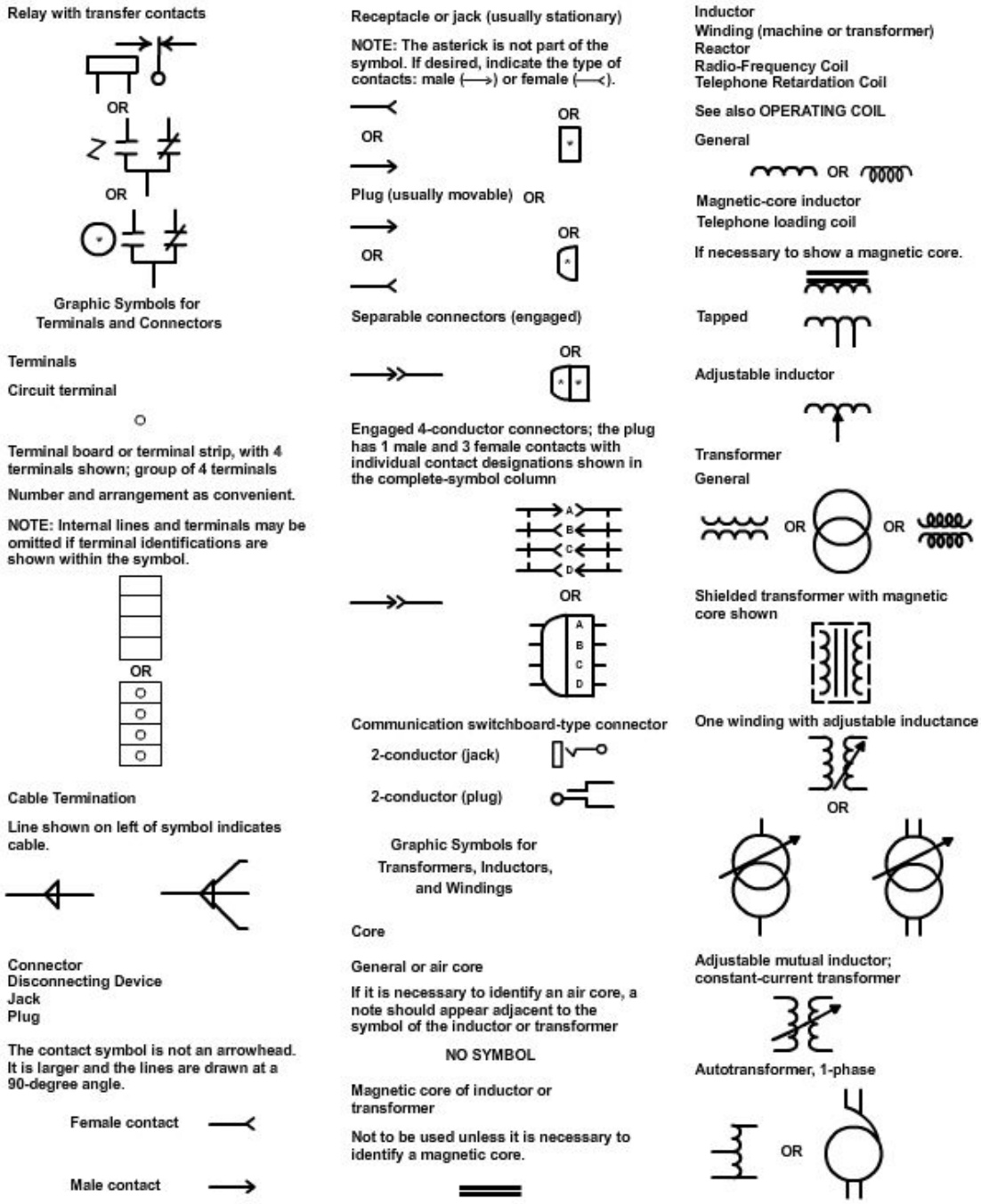


Figure 3-2 – Electrical symbols used in construction continued.

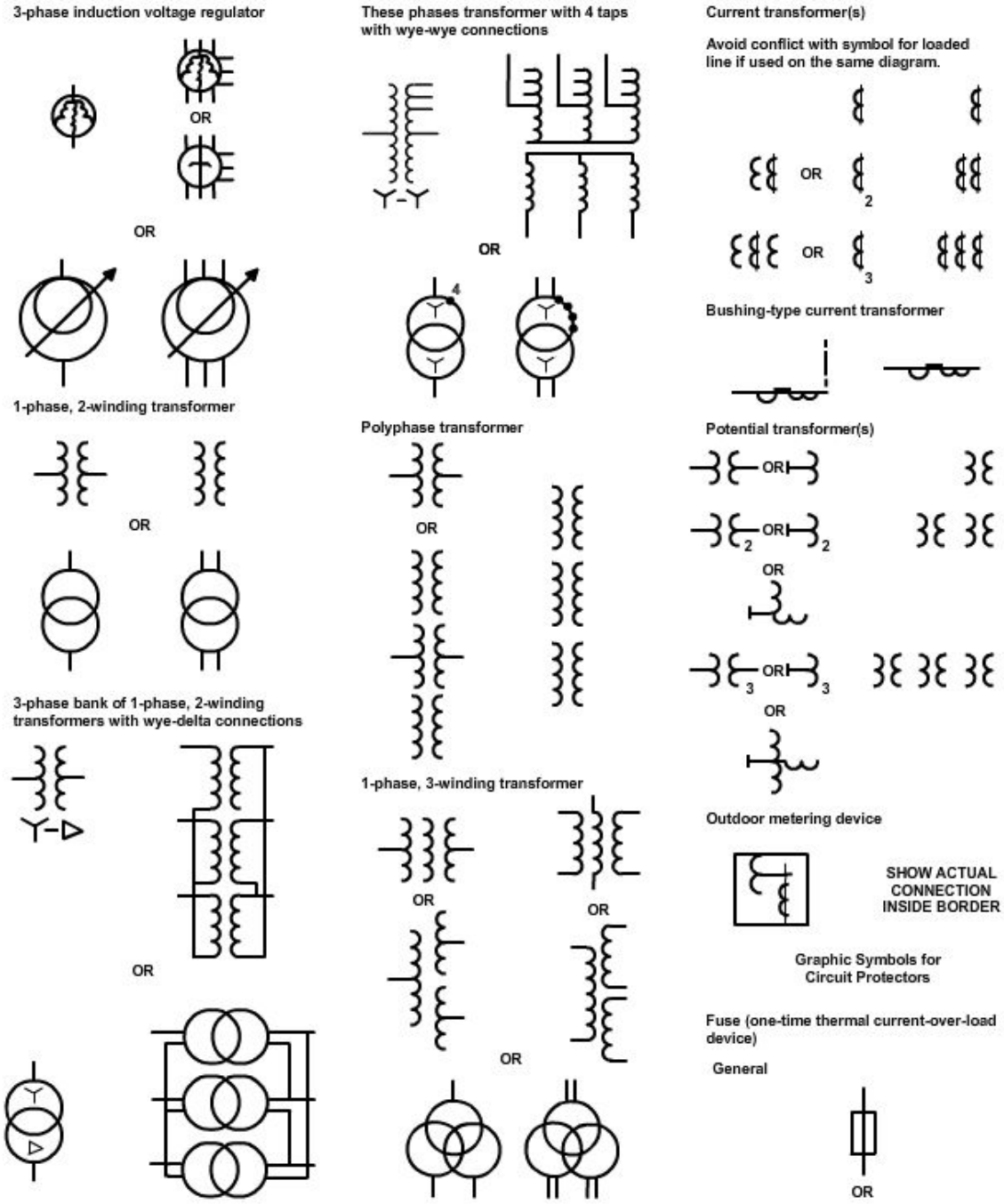


Figure 3-2 – Electrical symbols used in construction continued.

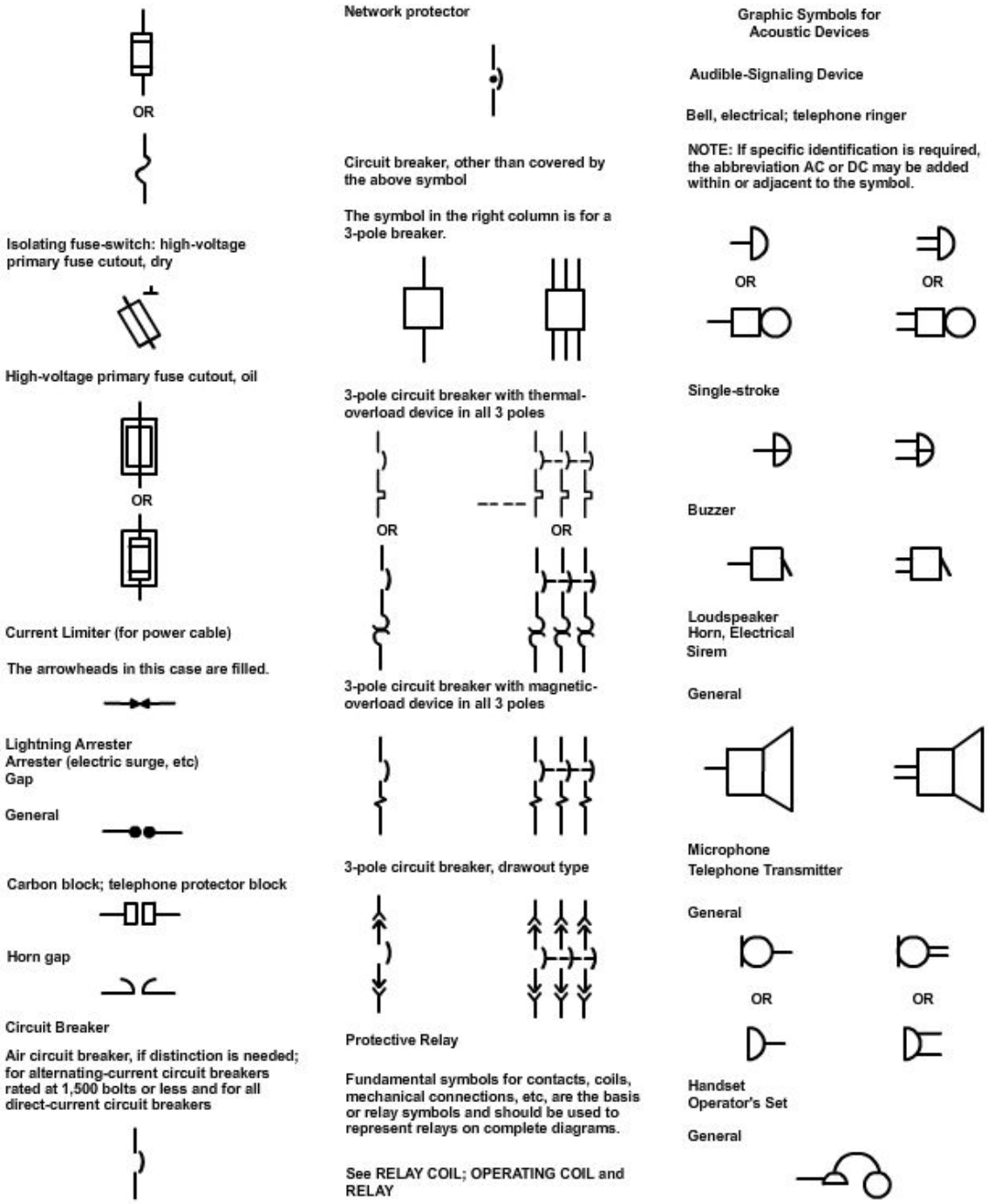


Figure 3-2 – Electrical symbols used in construction continued.

Telephone Receiver
Earphone

General

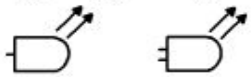
Headset, double

Headset, single

Graphic Symbols for Lamps and Visual-Signaling Devices

Lamp

Lamp, general; light source, general



NOTE: This symbol may be used to represent one or more lamps with or without operating auxiliaries.

NOTE: If it is essential to indicate the following characteristics, the specified letter or letters may be inserted within or placed adjacent to the symbol.

A	Amber
B	Blue
C	Clear
G	Green
O	Orange
OP	Opelescent
P	Purple
R	Red
W	White
Y	Yellow
ARC	Arc
EL	Electroluminescent
FL	Fluorescent
HG	Mercury vapor
IN	Incandescent
IR	Infrared
NA	Sodium vapor
NE	Neon
UV	Ultraviolet
XE	Xenon
LED	Light-emitting diode

Fluorescent lamp

2-terminal

4-terminal

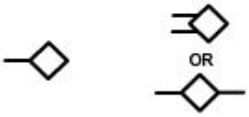
Incandescent lamp (incandescent-filament illuminating lamp

Ballest lamp; ballast tube

The primary characteristic of the element within the circle is designed to vary non-linearity with the temperature of the element.

Visual-Signaling Device

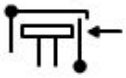
Annunciator (general)



Annunciator drop or signal, shutter or grid type

Annunciator drop or signal, ball type

Manually restored drop



Electrically restored drop

Communication switchgoard-type lamp; indicating lamp

Indicating, pilot, signaling, or switch-board light; indicator light signal light

If confusion with other circular symbols may occur, the D-shape symbol should be used.

OR

OR

Jeweled signal light

Graphic Symbols for Readout Devices

Meter Instrument

NOTE: The asterisk is not part of the symbol. Always replace the asterisk by one of the following letter combinations, depending on the function of the meter or instrument, unless some other identification is provided in the circle and explained on the diagram.

A	Ammeter
AH	Ampere-hour meter
C	Coulombmeter
CMA	Contact-making (or breaking) ammeter
CMC	Contact-making (orbreaking) clock
CMV	Contact-making (or breaking) voltmeter
CRO	Oscilloscope Cathode-ray oscillograph
DB	DB (decibel) meter Audio level/meter
DBM	DBM (decibels referred to 1 milliwatt) meter
DM	Demand meter
DTR	Demand-totalizing relay
F	Frequency meter
GD	Ground detector
I	Indicating meter
µ A or UA	Microammeter
MA	Milliammeter
NM	Noise Meter
OHM	Ohmmeter
OP	Oil pressure meter
OSCG	Oscillograph
PF	Power factor meter
PH	Phasemeter
PI	Position indicator
RD	Recording demand meter
REC	Recording meter
RF	Reactive factor meter
SY	Synchroscope
t°	Temperature meter
THC	Thermal converter
TLM	Telemeter
TT	Total time meter Elapsed time meter
V	Voltmeter
VA	Volt-ammeter
VAR	Varmeter
VARH	Varhour meter
VI	Volume indicator Audio-level meter
VU	Standard volume indicator Audio-level meter
W	Wattmeter
WH	Watthour meterv

Figure 3-2 – Electrical symbols used in construction continued.

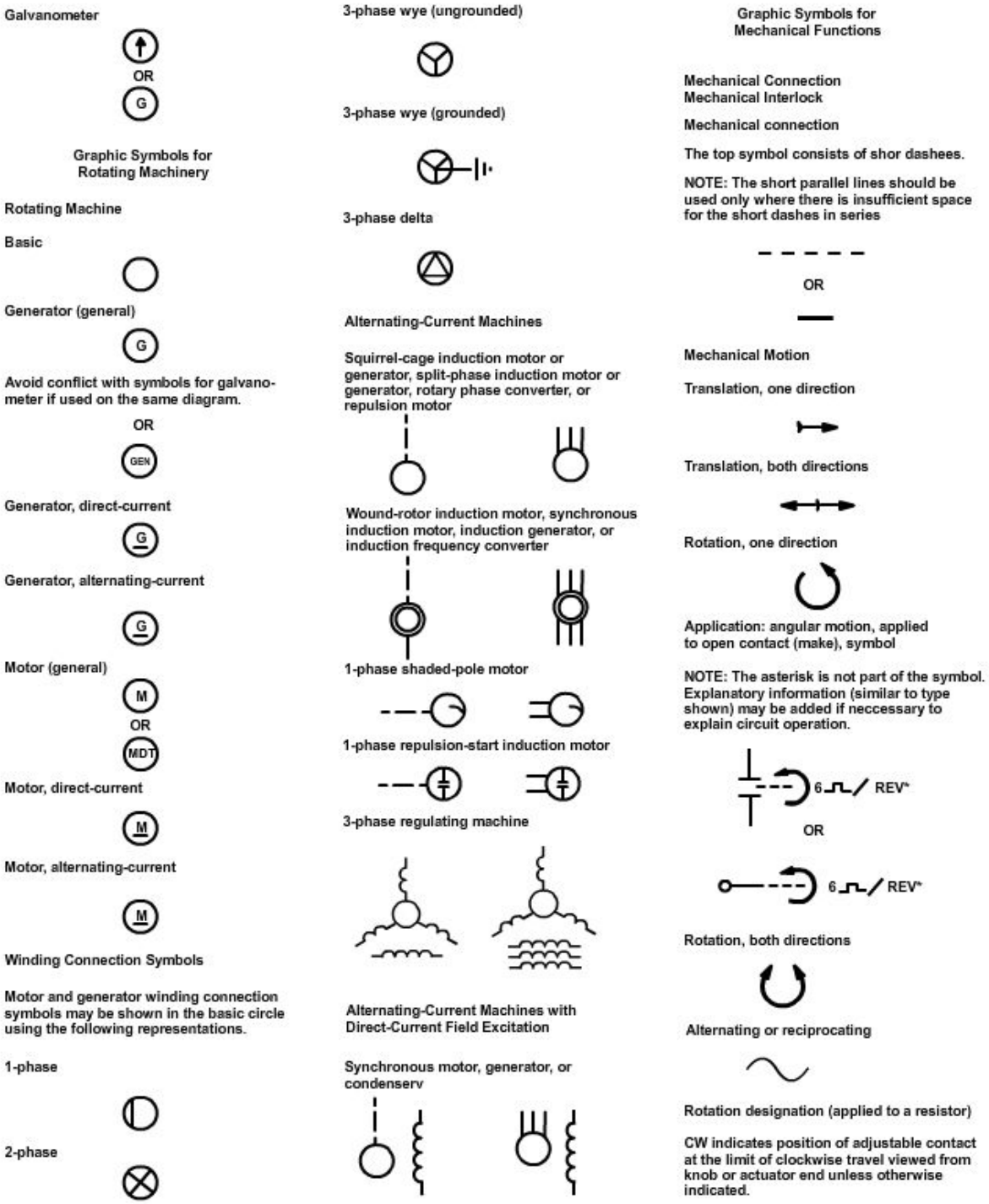
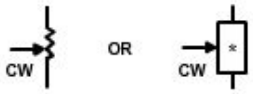


Figure 3-2 – Electrical symbols used in construction continued.

NOTE: The asterisk is not part of the symbol. Always add identification within or adjacent to the rectangle.



Manual Control

General

Operated by pushing

Operated by pushing and pulling (pudh-pull)

Graphic Symbols for Composite Assemblies

Circuit Assembly
Circuit Subassembly
Circuit Element

NOTE: The asterisk is not part of the symbol. Always indicate the type of apparatus by appropriate words or letters.

NOTE: The use of a general circuit-element symbol is restricted to the following:

a. Diagrams drawn in block form.
b. A substitute for complex circuit elements when the internal operation of the circuit element is not important of the purpose of the diagram.

General

Accepted abbreviations from ANSI Z32.13-1950 may be used in the rectangle.

The following letter combinations may be used in the rectangle:

CLK	Clock
EQ	Equalizer
FAX	Facsimile set
FL	Filter
IND	Indicator
PS	Power supply
RG	Recording unit
RU	Reproducing unit
DIAL	Telephone dial
TEL	Telephone station
TPR	Teleprinter
TTY	Teletypewriter

Amplifier

General

The triangle is pointed in the direction of transmission.

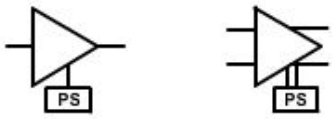
The symbol represents any method of amplification (electron tube, solid-state device, magnetic device, etc).

NOTE: If identification, electrical values, location data, and similar information must be noted within symbol, the size or aspect ratio of the original symbol may be altered providing its distinctive shape is retained.

Amplifier use may be indicated in the triangle by words, standard abbreviations, or a letter combination from the following list:

BOG	Bridging
BST	Booster
CMP	Compression
EXP	Direct-current
LIM	Limiting
MON	Monitoring
PGM	Program
PRE	Preliminary
PWR	Power
TRQ	Torque

Application: amplifier with associated power supply



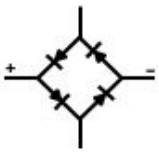
General

NOTE: Triangle points in direction of forward (easy) current as indicated by a direct-current ammeter, unless otherwise noted adjacent to the symbol. Electron flow is in the opposite direction.

NOTE: This symbol represents any method of rectification (electron tube, solid-state device, electrochemical device, etc).

Controlled

Bridge-type rectifier



On connection or wiring diagrams, rectifier may be shown with terminals and plarity marking. Heavy line may be used to indicate nameplate or positive-polarity end.

For connection or wiring diagram

Figure 3-2 – Electrical symbols used in construction continued.

2.4.0 Types and Weights of Lines Found on Drawings

Figure 3-3 shows the types of lines an electrician must be able to read and understand. These lines are shown as they may appear on a drawing.

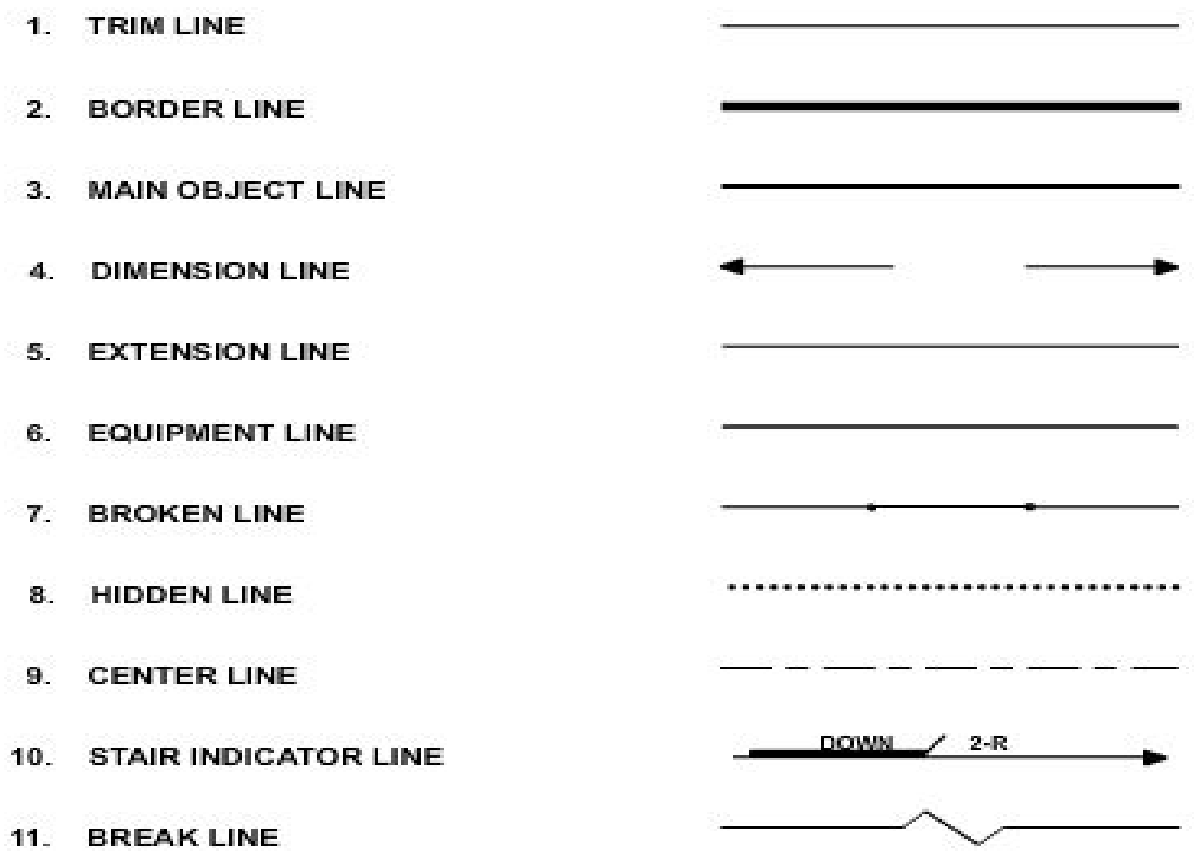


Figure 3-3 − Construction drawing lines.

Trim line: a light, continuous line along which the tracing is trimmed to square the sheet.

Border line: a heavy, continuous line that outlines or borders the drawing. The drawing is complete within this lined border.

Main object line: a heavy, unbroken line used to show visible outlines or edges that would be seen by people looking at the article, house, or building. The main object line is one of the most important lines because it outlines the main wall lines on plans and sections. It shows clearly the important parts of the construction and emphasizes the outline of the elevations.

Dimension line: a light line drawing outside the structure or detail to show the distance between two points. This thin line is drawn between extension lines with an arrowhead terminated on each end. Between the arrowheads, the distance will be given either at a break in the line or just above the line. On some drawings, the scale and the distance between the two points may not agree; in such cases, the distance will be given in a dimension line.

Extension line: a line that touches and is used with dimension lines. This line extends out from the edge or the point at which the dimension is to be determined.

Equipment line: a light, continuous, unbroken line used to show the location of equipment, such as transformers, panels, and galley equipment. This line is used to allow the electrician to install the necessary conduit in the proper location during rough-in work.

Broken line: a line with wavy breaks in it at intervals. It is used to indicate those parts that have been left out or to indicate that the full length of some part has not been drawn. The broken line is used in detail drawings where only a section of the object is to be shown.

Hidden (Invisible) line: a line that is made up of medium lines with short evenly spaced dashes. It is used to indicate an edge or edges hidden under some other part of the structure or concealed edges.

Center line: a line that is made up of thin lines made up of alternating long and short dashes and is used to indicate the center of an object and symmetry about an axis.

Section line: a solid line that has arrowheads at each end that point in the direction in which the section is to be built. This line tells just where the section line has been cut through the wall or building. The sections are indicated, in most cases, by the letters *A-A, B-B,* and so forth, although numbers are sometimes used. Do not overlook these section lines on a plan. To obtain a clear picture of the construction at the particular point indicated, always refer to the section detail called for by the letter or number.

Stair indicator line: a solid line with an arrowhead indicating the direction of the run. For example, Up 12-R means that there are 12 risers from floor to floor and that the stairs go up. A riser is the vertical part of the step; the flat part on which one steps is the tread. In most cases, the floor plan indicates only the run of stairs half the distance between floors. For example, the ground floor indicates a broken line that tells you the steps continue up. The next floor plan shows the stair indicator line half the distance to the first floor, down.

Break line: a thin solid-ruled line with freehand zigzags used to reduce the size of a drawing required to delineate an object and reduce detail.

2.5.0 Schedules

The schedule is a systematic method of presenting notes and information in tabular form to make it easily accessible to the craftsman and specification writer. One example of a commonly used lighting fixture schedule is shown in *Figure 3-4.* Similar schedules such as the room finish schedule and the mechanical equipment schedule (not shown) are very helpful and also should be reviewed.

LIGHTING FIXTURE SCHEDULE					
MARK	DESCRIPTION	MTG	VOLT	LAMPS	REMARKS
A	AUKCD # EXPRC-210-2E/120W/GREEN LETTER ON CLEAR	CEILING	277	(2) 6 WTS	W/FLASHER
B	METALUX # SS 240-277-ES	PENDANT	277	(2)F40/W/WR S/ WM	W/1 1/2 HR BATT PACK
C	ROBERT MFG # T2-240-277-ES	SURFACE	277	(2)F40/W/WR S/ WM	W/1 1/2 HR BATT PACK
D	METALUX # HR-2GP-ASR-3 40A-125-277-LE3	RECESSED	277	(3)F40/W/WR S/ WM	BLDG STANDARDS
E	CROUSE HINDS # VXH B1SGP	WALL	120	(1)150W/A21/ 120V	
F	METALUX #HR-2GP2ASR23 40A-12A277ALE3	RECESSED	277	(3)F40/W/WR S/ WHI	BLDG STANDARDS W/1 1/2 HR BATT PACK
G	SURE LITE # SWV-36	RECESSED	120/6	SUPPLIED W/ FIXTURE	W/1 1/2 HR BATT PACK
H	METALUX # SS 230-277-ES	COVE	277	(2)F40/W/WRS/ WM	
I	METALUX # SS 240-277-ES	PENDANT	277	(2)F40/W/WR S/ WM	
J	LIGHTOLIER # JAW/04/I	WALL	120	(1)60W/S-40/CL	BLACK W/CLEAN SPERE

Figure 3-4 − Schedule representing commonly used lighting fixtures.

2.6.0 Scale Representation

An architect cannot make his drawings full size. For convenience, he reduces all dimensions to some scale. He selects some smaller dimension to represent a foot and reduces all dimensions to this unit. A floor plan or an elevation is often drawn at l/48 the size of the real building. A drawing 1/48th size would be drawn at a scale of 1/4" = 1'0". Each l/4 inch on the drawing equals 1 foot on the actual building. Different scales are used to show different areas of the drawings. While floor plans and elevations are commonly drawn l/4" = 1'0", detail drawings are drawn at a larger scale, usually 1" = 1’0”. Sometimes full-scale drawings are used to show a small detail. The scale is normally noted in the title block or beside each drawing on the print.

Scaled drawings are made using an architect's scale (*Figure 3-5*). An architect's scale has 11 scales (*Table 3-1*). The numbers at each end of the architect's scale designate the scale. *Figure 3-6* shows an enlarged view of part of an l/4-inch scale. Each division on the scale equals 1 foot on the actual building. The small divisions to the right equal 1 inch on the building, thereby allowing more accurate measurement. This scale is read from right to left. Architects and drafters use an architectural scale to draw blueprints. *Figure 3-7* shows how the scale is used to check a measurement on a blueprint. Note how the small divisions (at the right) are used to get exact measurements, in this case, 8 feet 8 inches.

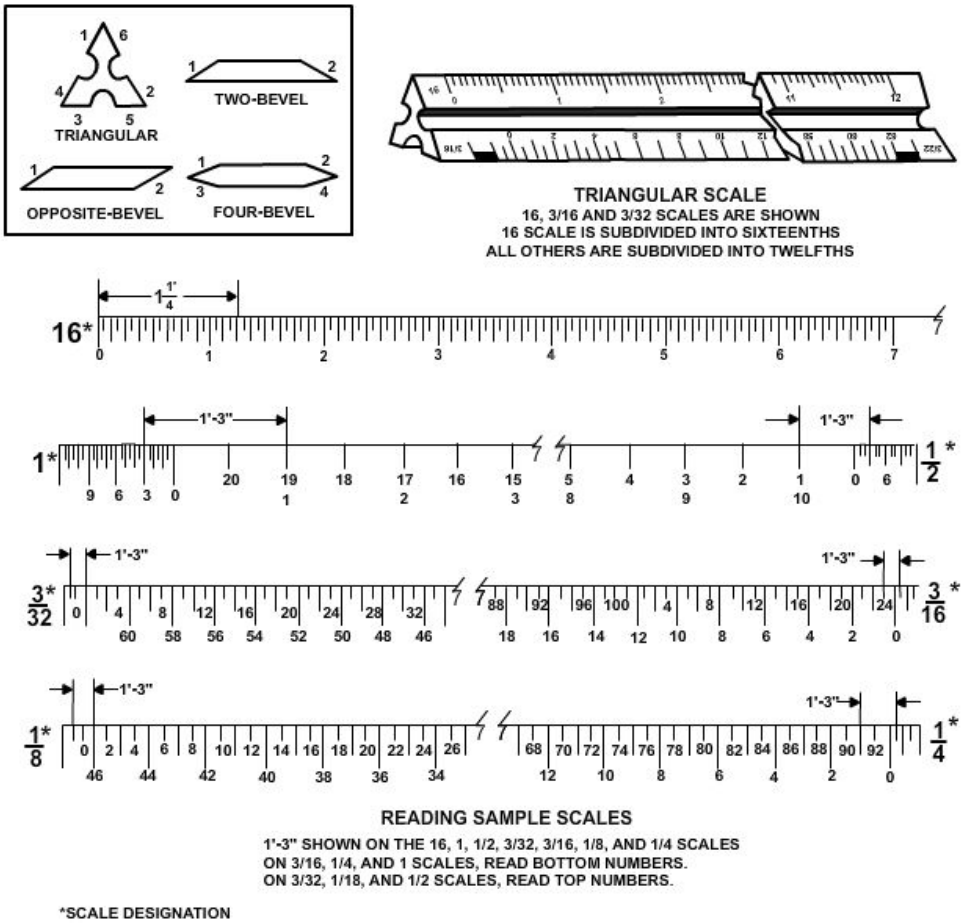


Figure 3-5 − Architect's scale.

Table 3-1 − Architect's Scales.

Scale	Relation of Scale to Object
16	1" = 1'
1/4	3" = 1'
1/8	1' 1/2" = 1'
1/12	1" = 1'
1/16	3/4" = 1'
1/24	1/2" = 1'
1/32	3/8" = 1'
1/48	1/4" = 1'
1/64	1/16" = 1'
1/96	1/8" = 1'
1/128	3/23" = 1'

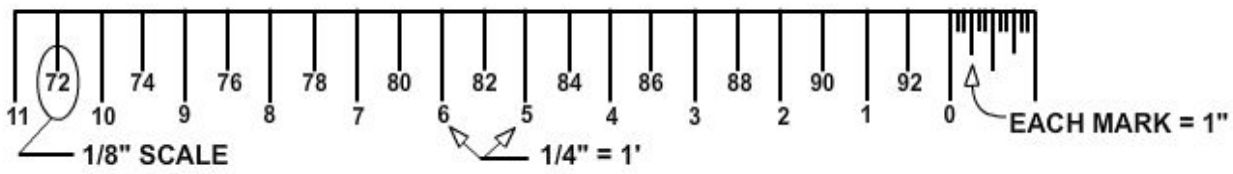


Figure 3-6 − Enlarged view of part of a 1/4 inch scale.

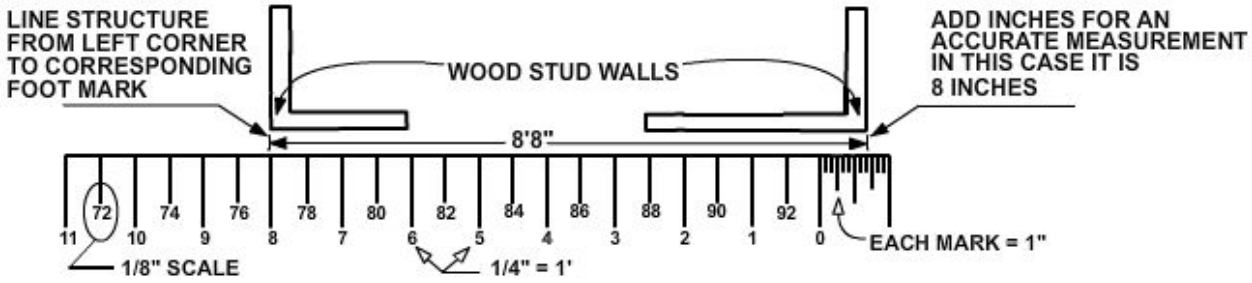


Figure 3-7 − Using a scale to check a measurement on a blueprint.

2.7.0 Modular Dimensions

Some blueprints are drawn so that features on the structure fall within a set module or measure. A modular system is based upon a grid with a set measure, normally 4 inches or a multiple of 4 inches, such as 16, 24, or 48 inches. Walls, floor levels, and openings are dimensioned to fall on 4-inch modular lines. This approach reduces building costs by coordinating building sizes with standard-sized building materials. For example, studs with finish are approximately 4 inches thick and are spaced on 16- or 24-inch centers. Plywood panels and drywall sheets come in standard 4-foot by 8-foot sheets.

Figure 3-8 shows a modular light-frame house used for a small residential building. The building is laid out in such a way that standard modular-based building materials can be used. Often, modular construction is used to develop complete, finished panels or rooms. This process allows standard-size building parts to be fabricated, taken to the building site, and erected into place.

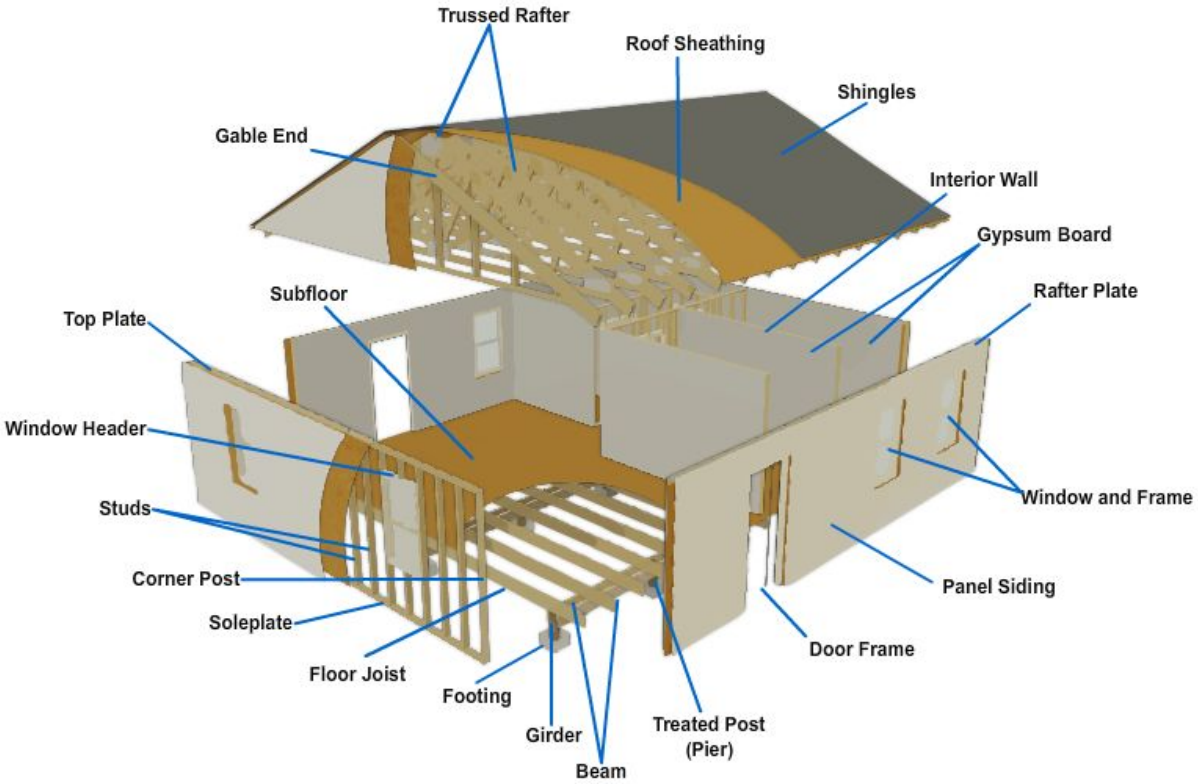


Figure 3-8 − Exploded view of a typical light frame modular house.

2.8.0 Metric Dimensions

Metric measurement is becoming more common in the United States on construction working drawings. NAVFAC drawings now have dimensions in both metric and English. The metric scale is used in place of the architect's and engineer's scales when measurements and dimensions are in meters and centimeters.

When you are using scales on a drawing, do not confuse the engineer's scale with a metric scale. They are very similar in appearance. You will often find metric dimensions used on blueprints from other countries. Metric drawings are dimensioned in millimeters (**mm**). There are 25.4 millimeters to an inch. A meter is 39.37 inches, a few inches longer than an English yard.

Scales of 1:100 and 1:200 are common scales for metric drawings. One millimeter on the drawing represents 100 or 200 millimeters on the actual building.

Metric blueprints developed in the United States are normally marked "METRIC." Those developed in countries that use the metric system-, however, have no metric notations.

Test your Knowledge (Select the Correct Response)

2. Which of the following categories is **NOT** part of a drawing index?

   A. Landscaping
   B. Fire Protection
   C. Technology Placement
   D. Irrigation

3. Which of the following construction drawing lines represents a hidden dimension?

   A. Broken
   B. Hidden
   C. Center
   D. Section

3.0.0 BLUEPRINTS

Blueprints are reproduced copies of mechanical or other types of technical drawings. The term ***blueprint reading*** means interpreting the ideas expressed by others on drawings whether the drawings are actually blueprints or not.

Drawing or sketching is the universal language used by engineers, technicians, and skilled craftsmen. Whether this drawing is made freehand or with drawing instruments, it is used to convey all the necessary information to the individual who will then fabricate and assemble the mechanical device.

3.1.0 Parts of a Blueprint

The size, format, location, and information included in the various blocks of military blueprints are prepared according to the Military Standards (ML-STD-100) (latest revision) Engineering Drawing Practices. American National Standard Institute (**ANSI**) is the mandatory publication used by the Navy for graphic (IEEE 315-1975) and electrical wiring (IEEE Y32.9-1972) symbols. Blueprints contain six parts. These standards are used on electrical diagrams and electrical drawings. The following paragraphs briefly describe the parts of a blueprint.

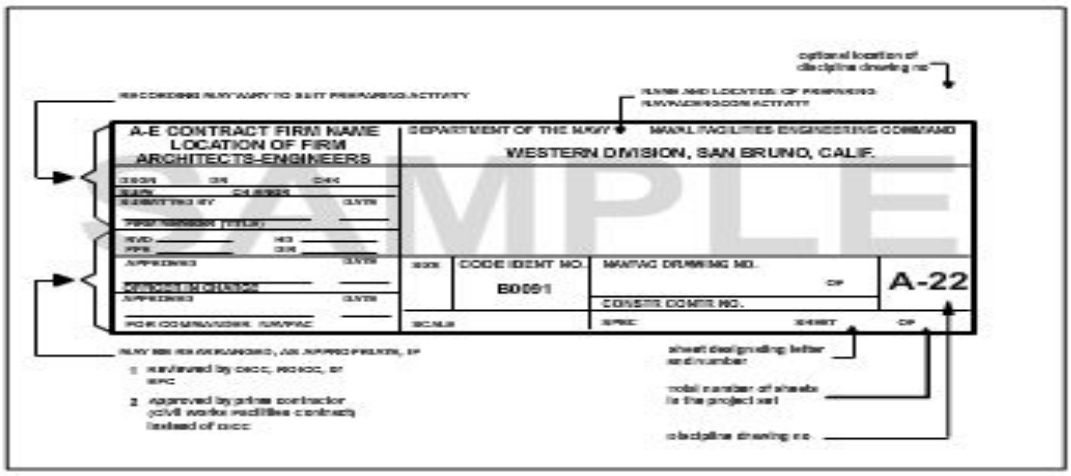


Figure 3-9 − Title Block.

3.1.1 Title Block

The requirements that determine what information must be included in a title block (*Figure 3-9*) vary. The title block, however, will always contain the title of the drawing, the signature of the approving authority, the drawing number, the sheet number (when the drawing is one of a set of several sheets), and the number of sheets in the project set.

The Naval Facility Engineering Command (**NAVFACENGCOM**) also requires the following information in title blocks: the name and location of the activity; the specifications and contract numbers (if any); the preparing activity, including the architect-engineer (**A-E**) firm, if applicable; and the surnames of the personnel concerned in the preparation of the drawings. The code identification number 80091 is to appear in the title block of all NAVFACENGCOM drawings as well as a sheet designation letter (I - Index, C - Civil, A - Architectural, S - Structural, M - Mechanical, P - Plumbing, E - Electrical, and W - Waterfront).

3.1.4 Drawing Number

All blueprints are identified by a drawing number that appears in a block in the lower right-hand comer of the title block. The drawing number is especially important, both for filing the blueprint and for locating it if it is specified on another blueprint.

3.1.3 Revision Block

The revision block is usually located in the upper right-hand comer of the blueprint and is used for recording changes (revisions) to the print. All revisions are noted in this block and are dated and identified by a letter and a brief description of the revision (*Figure 3-10*).

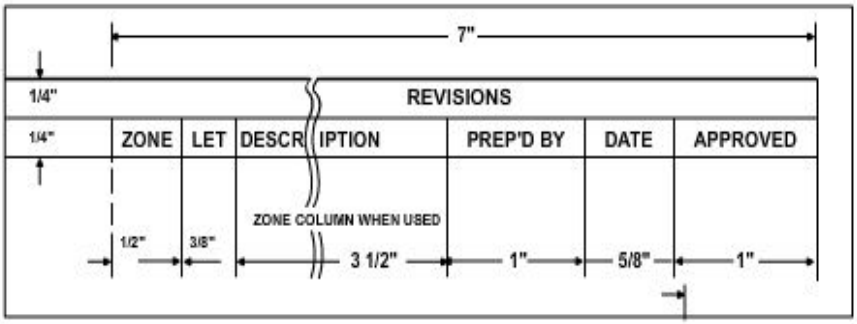


Figure 3-10 − Revision Block.

3.1.4 Scale

The graphic representation of the project is drawn to some proportion of the actual size of the project. One-eighth inch on such a drawing is equal to a foot of the actual size of the project. Although the original drawing is scaled accurately, your drawing will be a copy of that original and will not likely be the same size as the original drawing. The copy may have been reduced slightly or may have stretched or shrunk because of temperature and humidity. Because of these factors, do not rely on measurements taken by laying a rule on the drawing. For example, do not assume that a number of units (as 1/8-inch increments) on the drawing is equal to that same number of feet on the project. This may or may not be true. The assumption can result in expensive and time-consuming rework. Play it safe and read the dimensions shown on the drawing.

3.1.5 Legend or Symbols

The legend, if used, is generally placed in the upper right-hand comer of a blueprint below the revision block. The legend explains or defines symbols or special marks placed on a blueprint. A symbol may have more than one meaning. It should be noted that not all symbols used are from a single standard. The important thing is that you understand the meaning of the symbols on the drawing on which you are working. The legend will give you that meaning. The legend in *Figure 3-11* shows the symbols and their meanings from the partial floor plan below it.

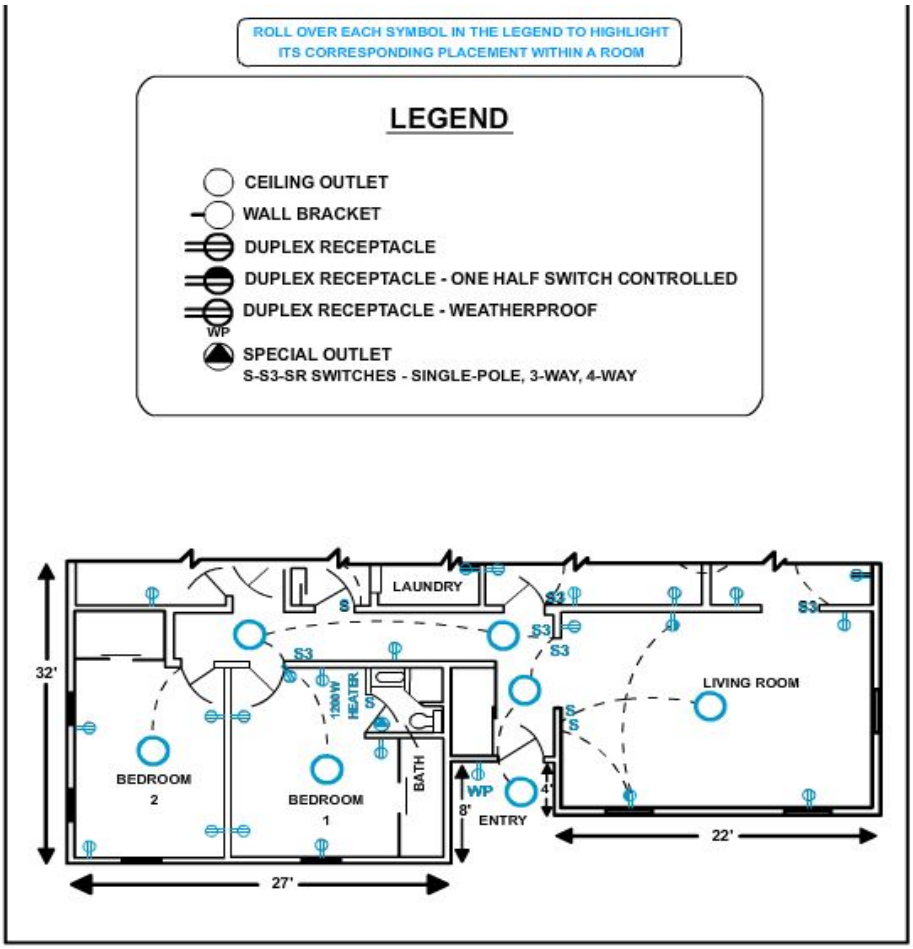


Figure 3-11 − Legend with partial floor plan.

3.1.6 Bill of Material

On a blueprint, the bill of material block contains a list of the parts and material, identified by stock number or other appropriate number, used on or required by the print concerned. The block also lists the quantity of those parts or materials used or required.

The bill of material often contains a list of standard parts, known as a parts list or schedule. Many commonly used items, such as machine bolts, screws, fittings, and valves, have been standardized by the military. *Figure 3-12 shows* a bill of material for an electrical plan.

BILL OF MATERIALS

ITEM NO.	DESCRIPTION	UNIT	ASSEMBLY OR FSN NO.	QUANTITIES	
				TROP	NONTROP
3-1	LIGHTING CIRCUIT - NAVFAC DWG NO 303414	EA	3016	1	1
3-2	POWER BUS, 100A - NAV DWG NO 304131	EA	3017	1	1
3-3	RECEPTACLE CKT - NAV DWG NO 303030	EA	3019	1	1
3-4	BOX, RECEPTACLE W/NO-LAMP FOR NON METALLIC SHEATH WIRE	EA	5325-100-304	1	1
3-5	LAMP ELECTRIC, MEDIUM BASE, INSIDE FROSTED, 300W/120V	EA	5240-100-314	30	30
3-6	PLUG: ATTACHMENT, 3 WIRE, 15 AMP, 125 V	EA	5326-100-309	10	10
3-7	PLATE: BRASS, DUPLEX RECEPTACLE	EA	5325-100-101	1	1
3-8	RECEPTACLE, DUPLEX, 3 WIRE, 15AMP, 125V	EA	5325-100-102	1	1
3-9	ROD, GROUND, 3/4" X 10'-0"	EA	5325-800-101	12	12
3-10	WIRE NO. 3 1/C STRANDED, HARD DRAWN, BARE	LB	5143-134-300	32	32
3-11	SWITCH, SAFETY, 2P, ST 30 AMP, 250 V PLUS FUSE	EA	5920-142-401	1	1
3-12	CLAMP, GROUND ROD	EA	5999-100-101	13	13
3-13	SWITCH, SAFETY 200 AMP, 250 V, 3 P	EA	5920-201-303	1	1
3-14	FUSE, RENEWABLE 200AMP, 250V	EA	5920-100-200	3	3
3-15	LINK FUSE 200 AMP, 250 V	EA	5920-100-201	3	3
3-16	FUSE PLUG, 30AMP, 125 V	EA	5920-100-102	12	12

Figure 3-12 − Bill of material.

Test your Knowledge (Select the Correct Response)

4. Preparation instructions for construction blueprints can be found in which of the following publications?

   A. ML-STD-100
   B. ML-STD-200
   C. ML-STD-300
   D. ML-STD-400

4.0.0 PLANS

You will be working with several types of plans and drawings. These may range from simple shop drawings and sketches, made perhaps by your immediate supervisor, to construction blueprints created by engineers. For the most part you will be working with plans created by architects and engineers. In Seabee construction, a complete set of plans for a project consists of civil, architectural, structural, electrical and mechanical plans, or drawings. You will spend the majority of your time with electrical drawings, but you will need all of these plans together to obtain a full picture of your part of a project and how to accomplish it.

4.1.0 Civil Plans

Civil plans, (also known as site or plot plans), encompass a variety of drawings and information. They furnish essential data about features, such as land contours, roads, utilities, trees, structures, site preparation and development, and significant physical features, on or near the construction site (*Figure 3-13*).

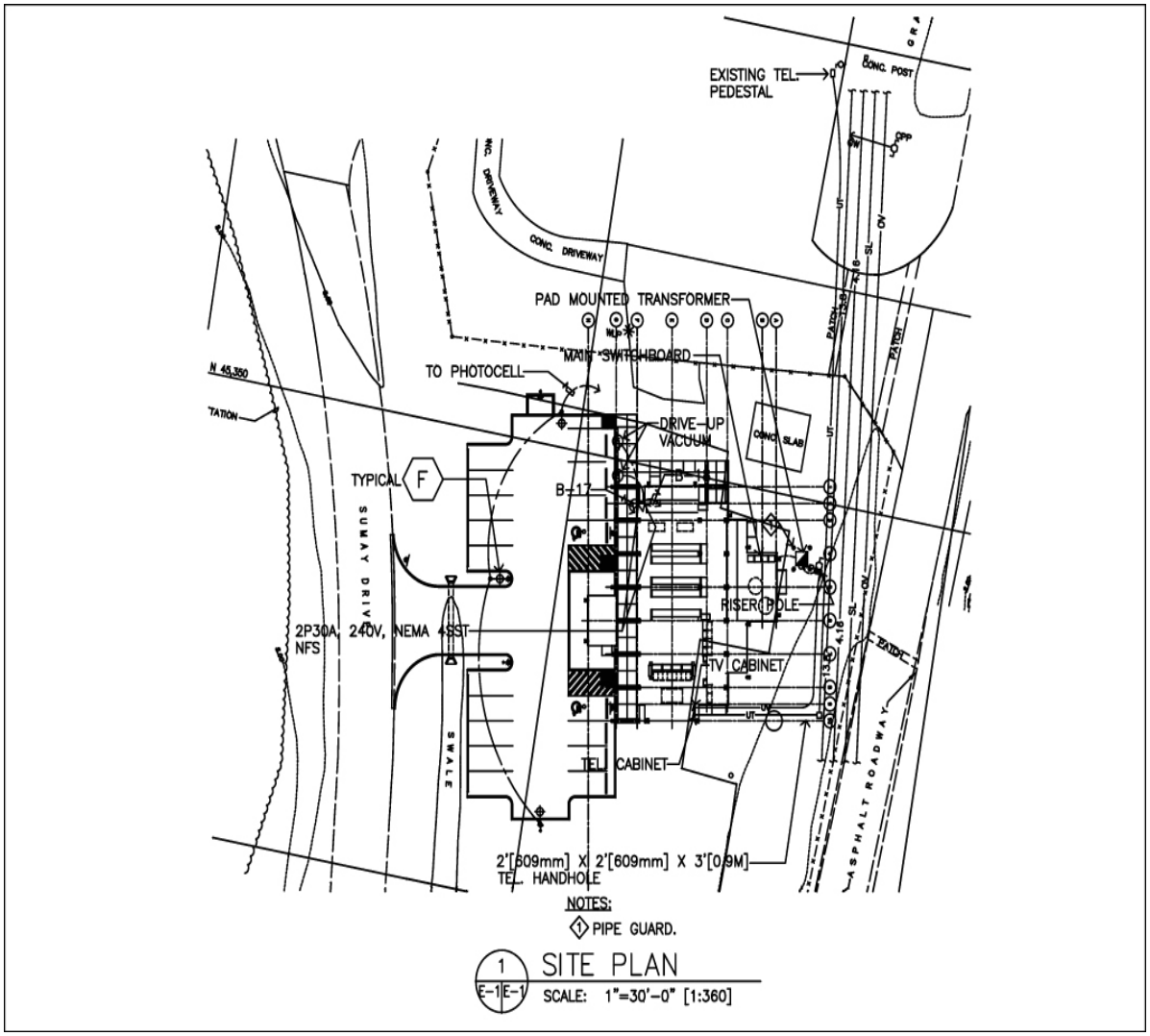


Figure 3-13 − Civil or site plan with existing utilities.

4.2.0 Architectural Plans

Architectural plans show the architectural design and composition of a building. They include floor plans, exterior elevation plans, and door and window schedules (*Figure 3-14*).

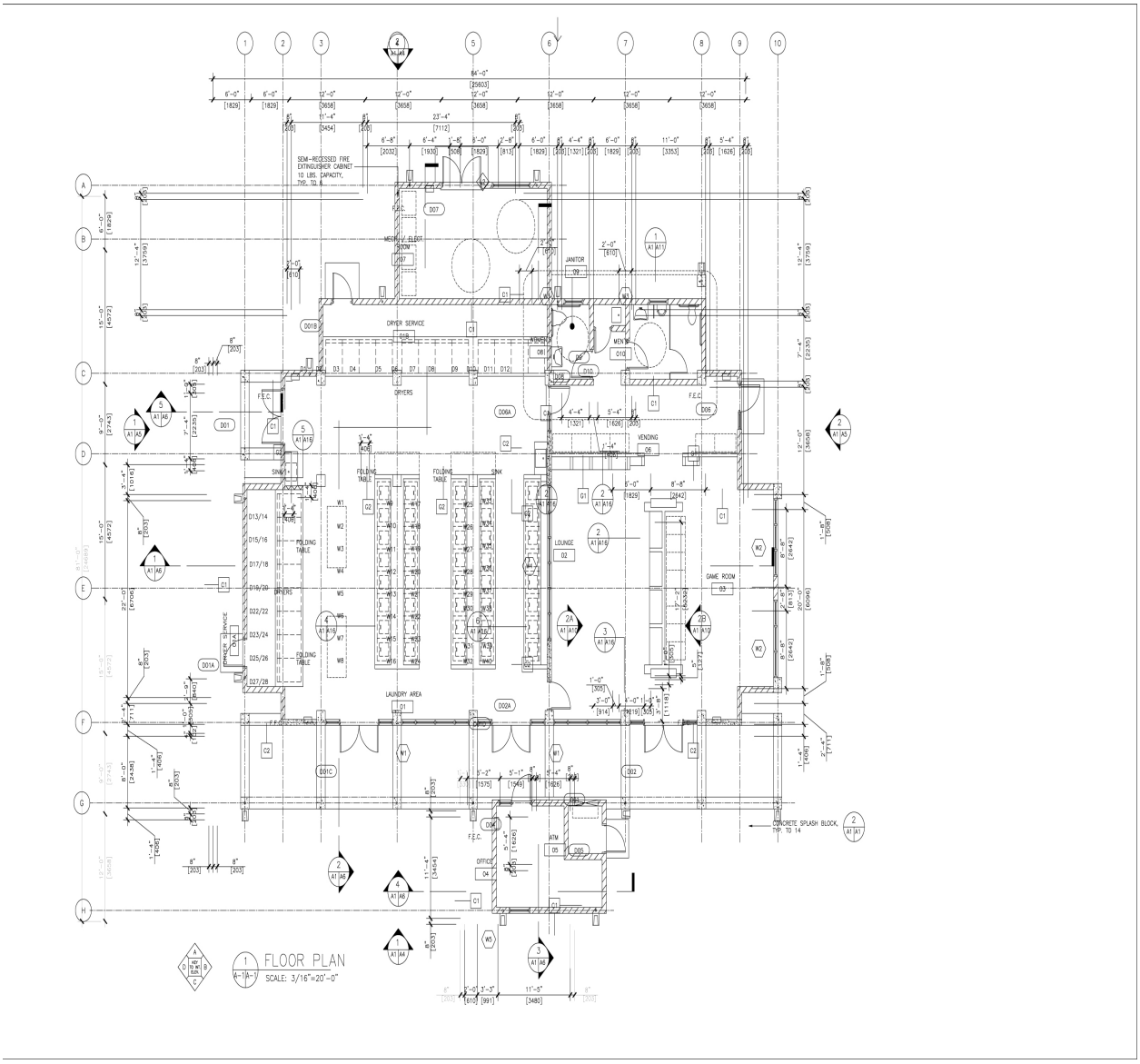


Figure 3-14 − Architectural or floor plan of concrete – masonry construction.

4.3.0 Structural Plans

Structural plans show the support of the building or structure, including walls, columns, beams, foundation, roof, and deck slab. They also show their relationship to each other (*Figures 3-15 and 3-16*).

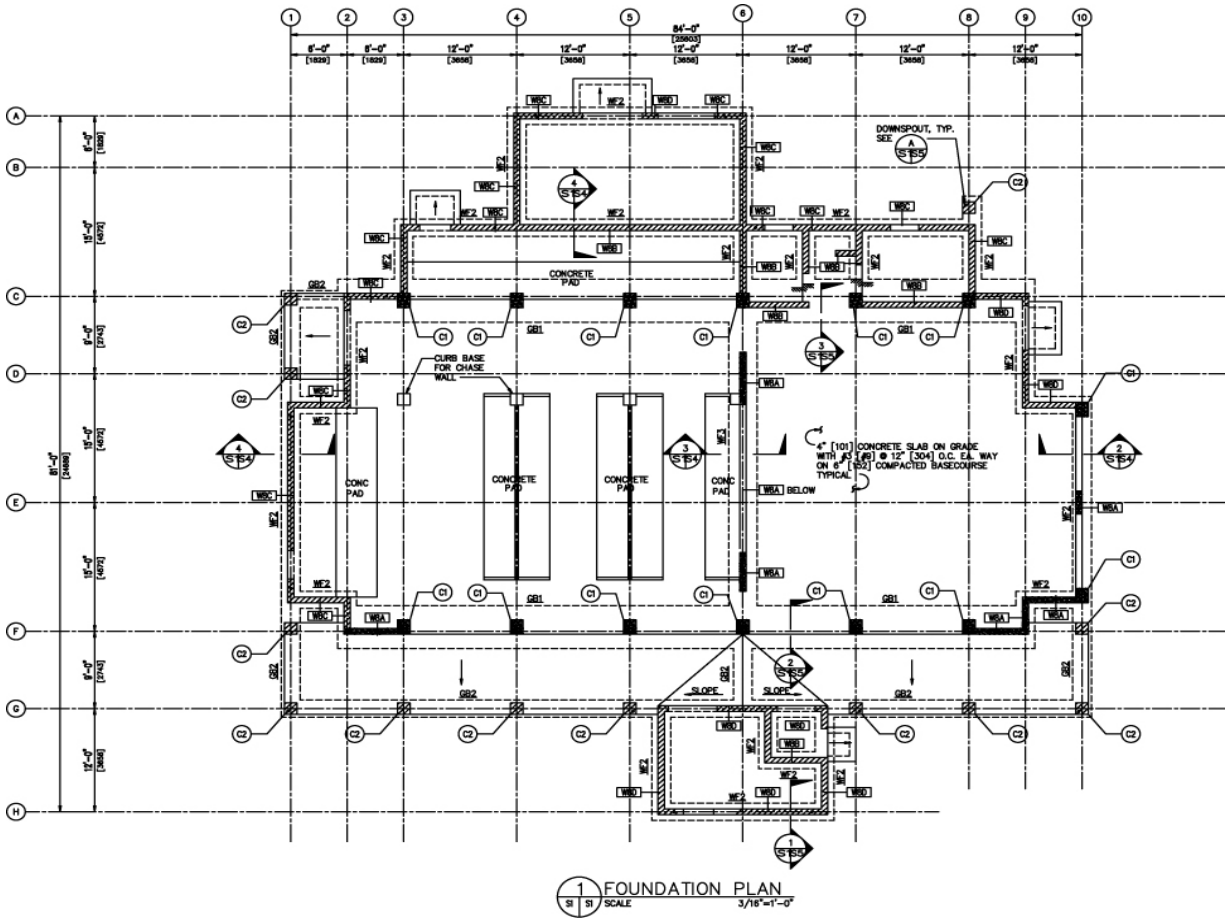


Figure 3-15 − Structural or foundation plan.

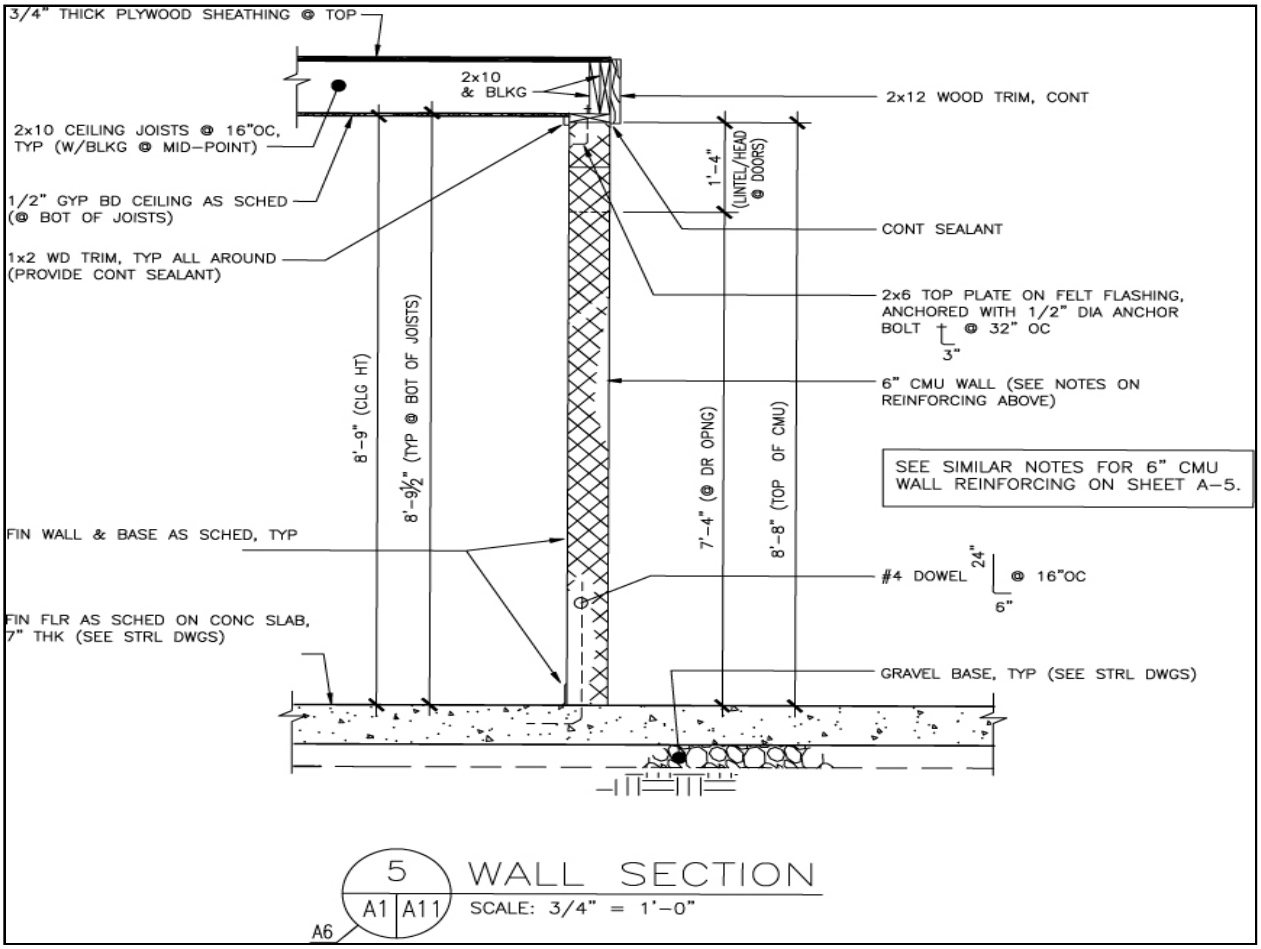


Figure 3-16 − Structural plan wall sections.

4.4.0 Electrical Plans

Electrical plans contain the electrical distribution system plans, interior wiring drawings, and electrical component schedules for a building, or structure. They show wiring circuits, light switches, receptacles, light fixtures, and equipment (*Figure 3-17*).

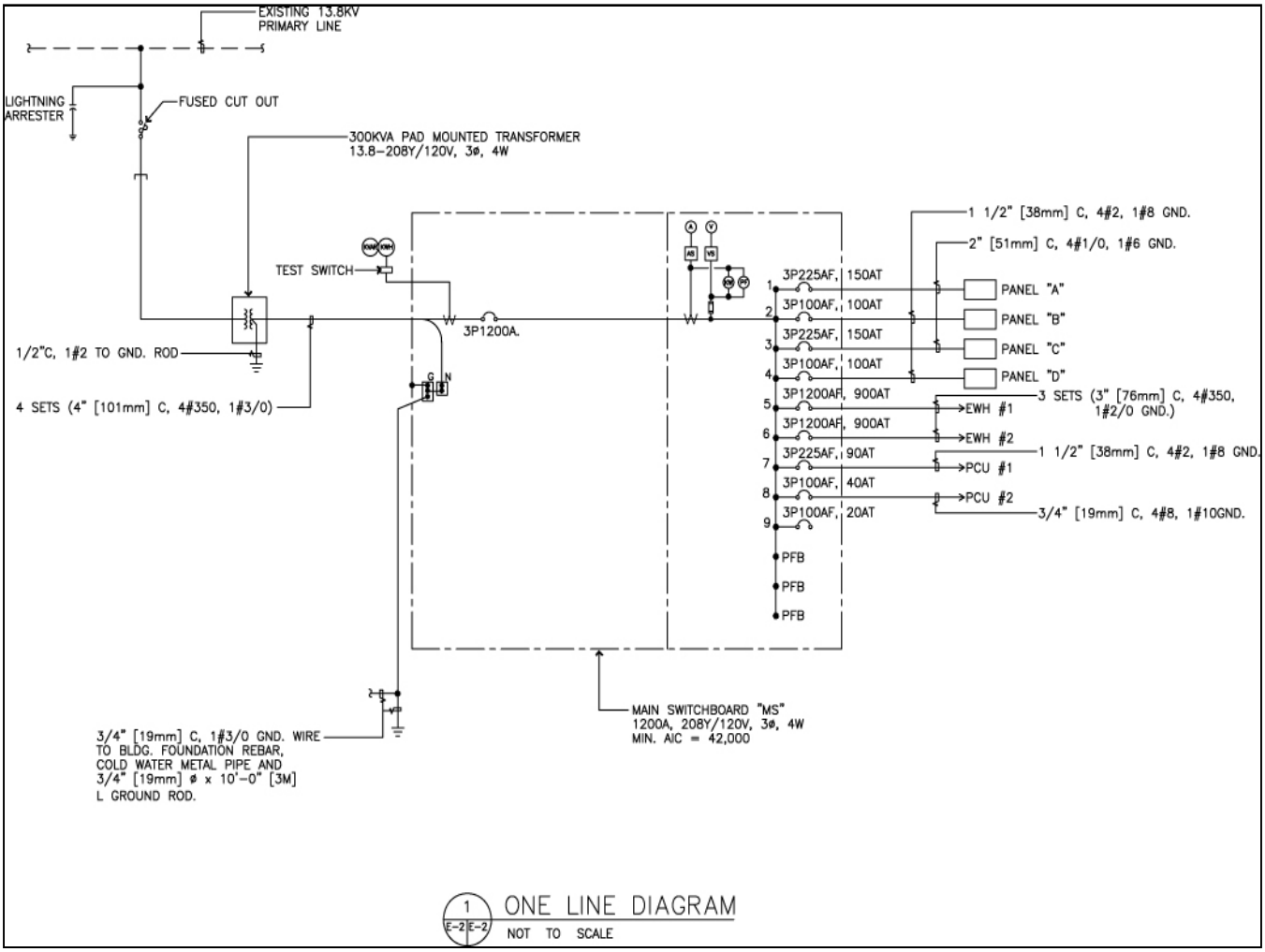


Figure 3-17 − Interior electrical plan.

4.5.0 Mechanical Plans

Mechanical plans include layouts and details for systems of plumbing, heating, ventilating, air conditioning, and refrigeration (*Figure 3-18*). These systems vary, depending on whether they are for a permanent installation with the most modern fixtures and equipment or for a temporary installation using less complex equipment. Whatever the job, you should work directly from the jobsite plans or working drawings, so the finished job is done properly and complies with the plans.

The chief parts of a mechanical plan are the views of the fixtures and equipment and the layout and details of the system. Plans also contain written information in the title block; the scales; the lines, symbols, and abbreviations; the print notes; the revision block; the drawing, reference, and zone numbers; and the bill of material.

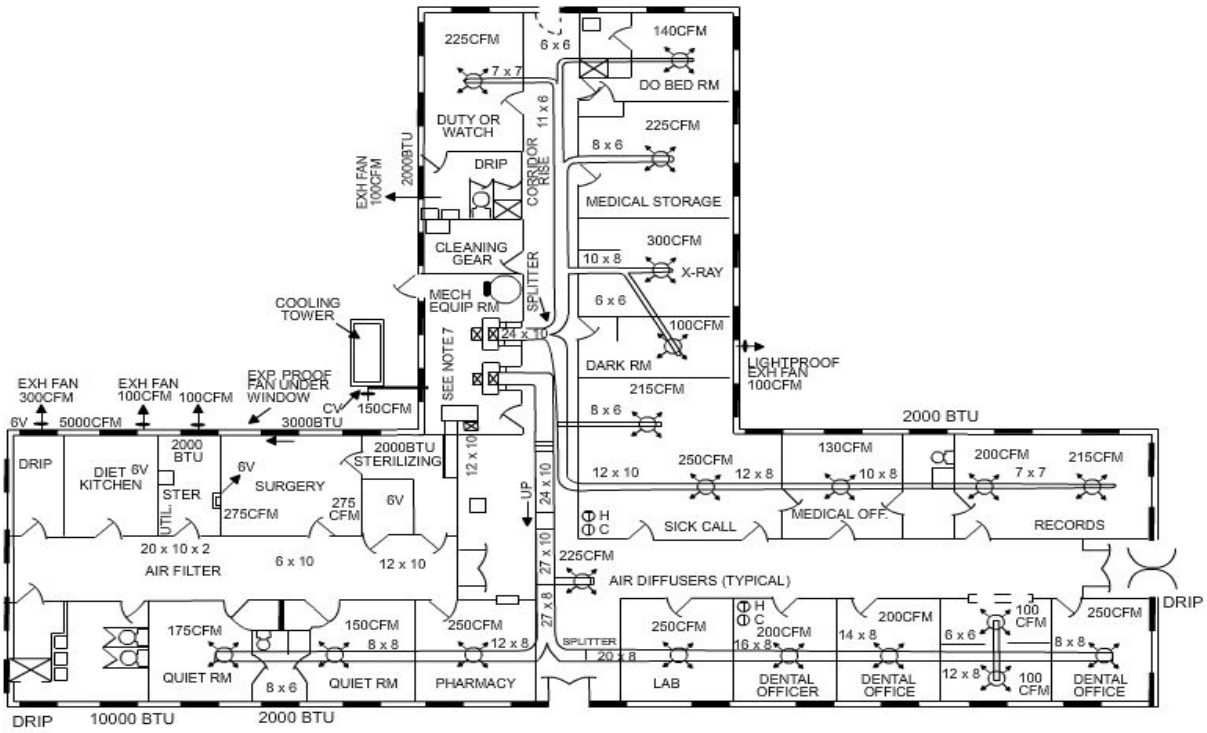


Figure 3-18 − Mechanical plan air conditioning system.

4.6.0 Isometric Sketching

You may not be able to sketch or draw objects exactly as they should look or as a two-dimensional orthographic picture. However, with the aid of some basic rules and practice, you can learn to draw an isometric sketch.

4.6.1 Purpose of the Isometric Drawing

The purpose of an isometric drawing is to show a three-dimensional picture in one drawing. It resembles a picture without the artistic details. Many Construction Electricians have difficulty visualizing an electrical wiring installation clearly when they work from a floor plan to an elevation drawing and back again. The isometric drawing combines the floor plan and the elevation. It clearly shows the details and relationships of the pipes in a piping installation.

Normally, isometric drawings are NOT drawn to scale on blueprints; however, when you sketch out an isometric drawing, you have the option of drawing it to scale.

The isometric drawing follows certain rules or conventions to show three dimensions on a flat surface. These rules are as follows:

1. Vertical lines in an orthographic elevation remain vertical in an isometric sketch.
2. Horizontal lines in an orthographic elevation are projected at an angle of 30 degrees and 60 degrees in an isometric drawing.

4.6.2 Comparison of Isometric and Orthographic Drawings

Compare the simple rectangular block shown in the orthographic representation in view A, *Figure 3-19*, and the three-dimensional-view isometric representation in view B. Notice that the vertical lines of the orthographic drawing and isometric drawing (views A and B) remain vertical. The horizontal lines of the orthographic drawing are NOT horizontal in the isometric drawing but are projected at 30-degree and 60 degree angles, and the length of the lines remains the same in the isometric as they were in the orthographic.

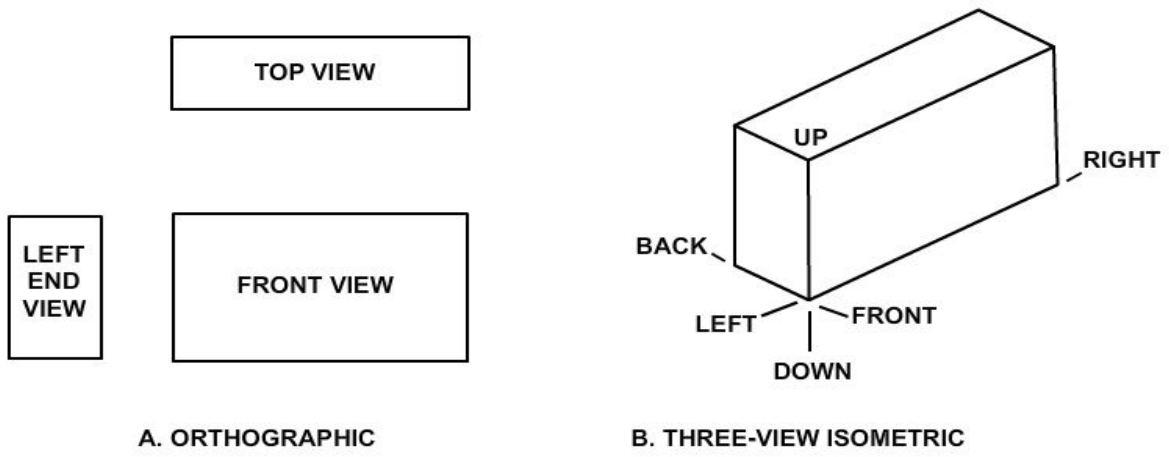


Figure 3-19 − Orthographic and isometric drawings.

Once you understand the drawing in *Figure 3-19*, the same idea can be applied to the drawing of the shape of a room, as shown in *Figures 3-20* and *3-21*.

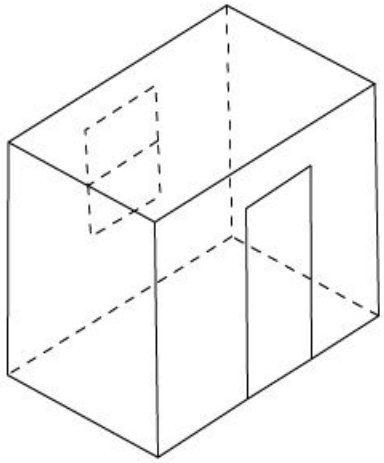


Figure 3-20 − Isometric drawing of a room.

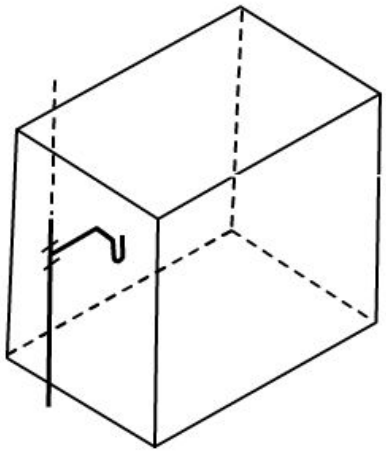


Figure 3-21 − Isometric drawing of a room and drainage pipe.

4.6.3 Drawing an Isometric View

To determine the pipe layout, you can draw the dimensions of a room in several ways. Some Engineering Aids suggest that the lines of the room be drawn with fine, light lines, and the pipe diagram with heavy, dark lines to give the effect of a transparent room you can see into, as shown in *Figure 3-22*. This method requires drafting room equipment and is difficult in field sketching.

Another means of visualizing the layout is to “section” or remove from the drawing those parts in front of what is important to show. The usual section in a electrical wiring layout leaves the ceiling and two walls out of the drawing, as shown in view C of *Figure 3-22*.

A third method is simpler in that the room is shown only in a partial floor plan view, as shown in view D, *Figure 3-22*. The walls are omitted from the drawing entirely. The walls are understood to be there, but they are left out of the drawing so that it shows the piping diagram without unnecessary details.

To lay out a 45-degree angle in an isometric drawing, draw a square and lay out the 45-degree angle, as shown in view A, *Figure 3-23*. Now look at view B and you will see a block with a 45-degree ***chamfer***. The chamfer is located by measuring equal distances from the corner that would ordinarily be there.

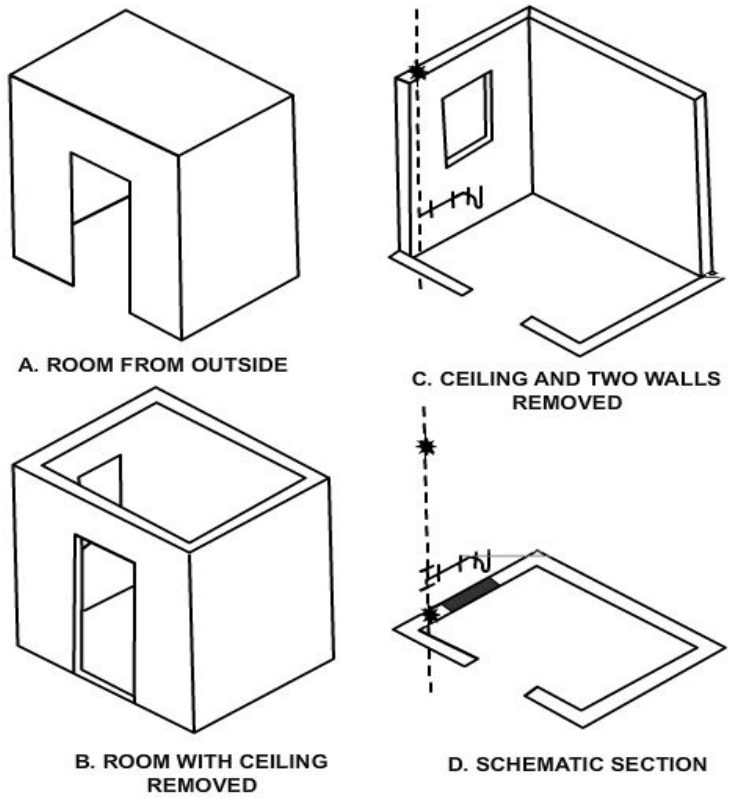


Figure 3-22 − Isometric layout.

A piping diagram with a 45-degree angle, as shown in view C, is very similar to the lines for part of the block, as shown in view B. To draw a 45-degree angle in an isometric drawing, begin with a 90-degree angle. Measure an equal distance from the intersection of the two legs connecting these points; then establish two sides of a square. By connecting these points, you have established the diagonal, which is a 45-degree angle. In view C, point A would be the intersection of the two legs of a 90-degree angle, measured an equal distance along each leg; three fourths of an inch is used here. Now, locate points B and C. Connect points B and C, and you have established the 45-degree offset.

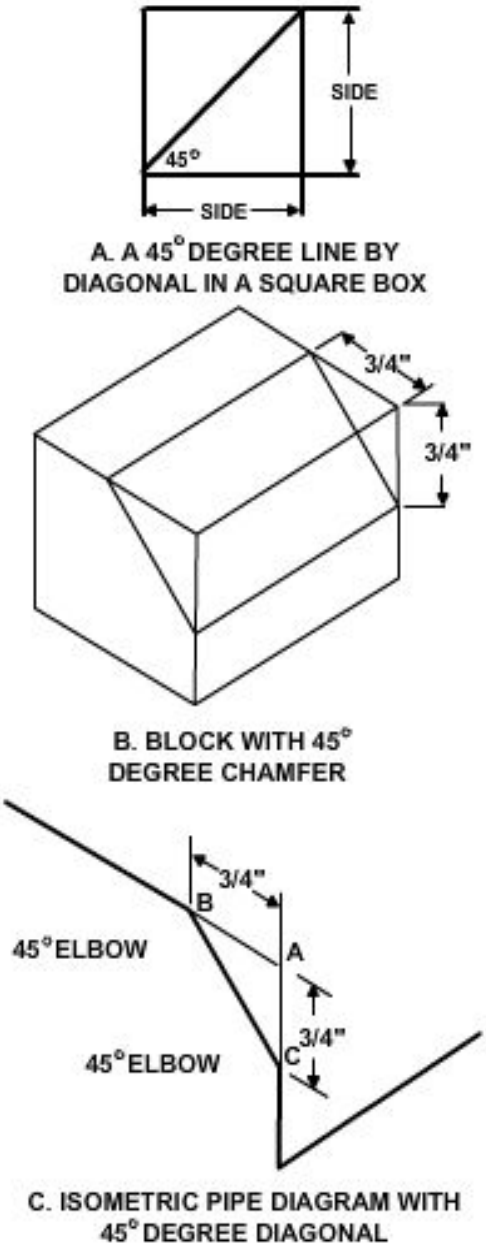


Figure 3-23 − Isometric 45-degree squares, chamfers, and diagonals.

4.6.4 Dimensioning an Isometric Drawing

An isometric drawing, or sketch, is dimensioned with extension and dimension lines nearly like a two-dimensional drawing. The extension lines extend from the drawing, so the dimension lines are parallel to the object line and of equal length to it.

The isometric drawing is more difficult to dimension because there is only a single view, and less room is available than on three separate views. *Figure 3-24* shows a dimensioned isometric drawing for part of a pipe hanger. In making the isometric pipe diagram, refer to the architect's plans and "rough in" sheets for accurate information.

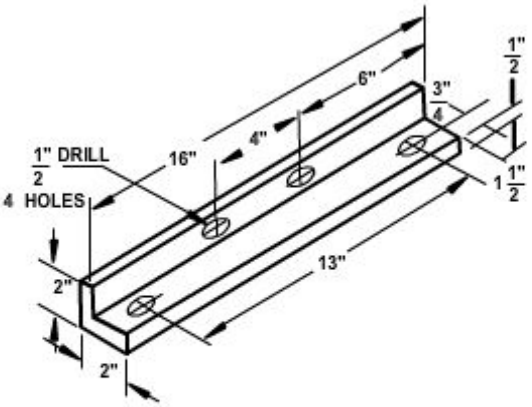


Figure 3-24 − Isometric drawing of a wiring hanger.

Test your Knowledge (Select the Correct Response)

5. Which of the following types of plans indicate foundation dimensions?

   A. Electrical
   B. Mechanical
   C. Structural
   D. Civil

5.0.0 SPECIFICATIONS

Even well-drawn construction drawings cannot adequately reveal all the aspects of a construction project. Many features cannot be shown graphically. For instance, how can anybody show on a drawing the quality of workmanship required for installation of electrical equipment or who is responsible for supplying the materials? These can only be done by extensive hand-lettered notes. The standard procedure then is to supplement construction drawings with written descriptions. These detailed written instructions, commonly called specifications (specs), define and limit the materials and fabrication according to the intent of the engineer or designer. The specifications are an important part of the project because they eliminate possible misinterpretation and ensure positive control of the construction.

There are many different types of specifications. A few of those common to the Naval Construction Force (**NCF**) will be discussed here.

5.1.0 NAVFACENGCOM Specifications

The Naval Facilities Engineering Command prepares the Naval Facilities Engineering Command (NAVFACENGCOM) specifications, which sets forth the standards of construction for the NCF and all work performed under the jurisdiction of the NAVFACENGCOM.

Several types of specifications influence the preparation of NCF project specifications. These include NAVFACENGCOM guide specifications and type specifications; commercial specifications and standards; technical society and association standards, such as American National Standards Institute (**ANSI**) and Underwriters Laboratories (**UL**); and manufacturers' standards.

5.2.0 Federal and Military Specifications

Federal specifications cover the characteristics of materials and supplies used jointly by the Navy and other government agencies. Federal specifications do not cover installation or workmanship for a particular project but specify the technical requirements and tests for materials, products, and services. Federal specifications dictate the minimum requirements acceptable for use of all federal agencies. The engineering technical library should contain all of the commonly used federal specifications pertinent to Seabee construction.

Military specifications are those specifications that have been developed by the Department of Defense. Like federal specifications, they also cover the characteristics of materials. They are identified by MIL preceding a letter then a serial number, e.g., MIL-L-19140C (lumber and plywood, fire-retardant treated).

Your main concern will be with project specifications. Even if you do not see them, you should know that they exist and what kind of information they include.

5.3.0 Project Specifications

Construction drawings are supplemented by written project specifications. Project specifications give detailed information regarding materials and methods of work for a particular construction project. They cover various factors relating to the project, such as general conditions, scope of work, quality of materials, standards of workmanship, and protection of finished work. The drawings, together with the project specifications, define the project in detail and show exactly how it is to be constructed. Usually, a set of

project specifications accompanies any set of drawings for an important project. The drawings and project specifications are inseparable. The drawings indicate what the project specifications do not cover, and the project specifications indicate what the drawings do not portray or clarify details not covered or amplified by the drawings and notes on the drawings. Whenever information on the drawings conflicts with project specifications, the project specifications take precedence.

The general requirements are usually the first specifications listed for the structure, stating the type of foundation, character of load-bearing members (wood frame, steel frame, or concrete), type or types of doors and windows, types of mechanical and electrical installations, and the principal function of the building. Next follows the specific conditions that must be carried out by the constructors. These are grouped in divisions (17) under headings applying to each major phase of construction, such as the following typical list of divisions:

1. GENERAL REQUIREMENTS
2. SITE WORK
3. CONCRETE
4. MASONRY
5. METALS
6. CARPENTRY
7. MOISTURE CONTROL
8. DOORS, WINDOWS, AND GLASS
9. FINISHES
10. SPECIALTIES
11. EQUIPMENT
12. FURNISHINGS
13. SPECIAL CONSTRUCTION
14. CONVEYING SYSTEMS
15. MECHANICAL
16. ELECTRICAL
17. EXPEDITIONARY STRUCTURES

Sections under one of these general categories sometimes begin with general requirements for that category. For example: under DIVISION 16 - ELECTRICAL, the first section might read as follows:

> 16. - 0l. - General Requirements. - Electrical installation must conform to the requirements of the National Electrical Code©. This includes all temporary work and the complete installation. The service entrance equipment must conform to the requirements of the local electric utility company if it is the source of electric power for the building or facility.

Subsequent sections under DIVISION 16. - ELECTRICAL would specify various quality criteria and standards of workmanship for the different types of electrical installation work; for example:

> 16. - 05. - Installation of Wires and Cables. Installation of wire in conduit is made with the use of pull lines or fish tapes and an approved wire-pulling lubricant.
>
> Suitable equipment should be provided to prevent cutting or abrasion of conductor insulation during the pulling of the wires. Lubricating compound must not have a harmful effect on the conductor insulating materials. All wires in a conduit are bundled and pulled at one time. Pulling lines are attached by direct connection to the conductors or by the use of a cable grip. Slack is provided at attachment of devices or splicing. In outlet boxes, for future installation of wiring devices, the ends of wires are insulated with tape or a suitable wire connector. All conductors of each circuit in a junction box containing multiple circuits must be permanently identified with suitable labels.

The moment your battalion or unit receives orders to undertake a major construction project, watch for the arrival of sets of drawings and specifications, which are usually provided well in advance of the deployment period. These drawings and specifications will also be the basis for the Planning & Estimating (**P&E**) and scheduling. Take a look at the specifications.

6.0.0 TYPES of DRAWINGS and DIAGRAMS

The types of drawings discussed here include working drawings, architectural drawings, mechanical drawings, shop drawings, and electrical diagrams.

6.1.0 Freehand Sketches

When installing electrical systems and circuits, you will sometimes have to exchange information about your job with others. A freehand sketch can be an accurate and concise way to communicate this information.

This type of drawing is informal in character, may or may not be drawn to scale, and need not follow any particular format. A sketch can be used in many ways. One example of how to use a sketch is to show a necessary field change. No matter how well a project is planned, occasionally field changes have to be made.

You may see that a field change is necessary because a conduit run cannot practically be routed according to the approved drawing or plan. You can make a freehand

sketch showing only what has to be changed. The sketch may include dimensions, symbols, and other information needed to convey to someone else (like the project supervisor or project chief) your idea of the required change.

6.2.0 Construction Drawings

A construction drawing is any drawing that furnishes the information required by the craftsmen to rough in equipment or erect a structure. The terms **working drawings** and **construction drawings** are sometimes used interchangeably. Information presented in a set of working drawings, along with the specifications, should be complete so the craftsman who uses them will require no further information.

Working drawings show the size, quantity, location, and relationship of the building parts. Generally, working drawings may be divided into three main categories: architectural, mechanical, and electrical.

Regardless of the category, working drawings serve several functions:

- They provide a basis for making material, labor, and equipment estimates before construction starts.
- They give instructions for construction, showing the sixes and location of the various parts.
- They provide a means of coordination between the different ratings.
- They complement the specifications; one source of information is incomplete without the other when drawings are used for construction work.

6.2.1 Architectural Drawings

Architectural drawings consist of all the drawings that describe the structural members of the building and their relationship to each other. This includes foundation plans, floor plans, framing plans, elevations, sections, details, schedules, and bills of materials.

6.2.2 Plans

A plan is a part of the architectural drawing that represents a view of the project from above. Two types of plans will be discussed here: plot plans and floor plans.

6.2.2.1 Plot Plans

A plot plan (also called a site or civil plan) includes not only the project but also the surrounding area. The plot plan may represent the project only by an outline, such as the Director's Quarters project on the plot plan in *Figure 3-25*. It shows the grades at fixed points throughout the area in order to show how the land slopes before construction is started and the finished grade after construction is completed. It also shows the north arrow symbol, used for orientation of the drawing. The Construction Electrician may have to have a plot plan to construct a pole line to the project site at or near the earliest phase of construction. Another example is when the slope and grade of the surrounding area requires change and you have to bury cable or conduit. You must know what the finished grade is and how deep to dig. This type of work requires close coordination between you, the Engineering Aids, Equipment Operators, and Builders. By looking over the plot plan, you will know what to do to prepare for the job.

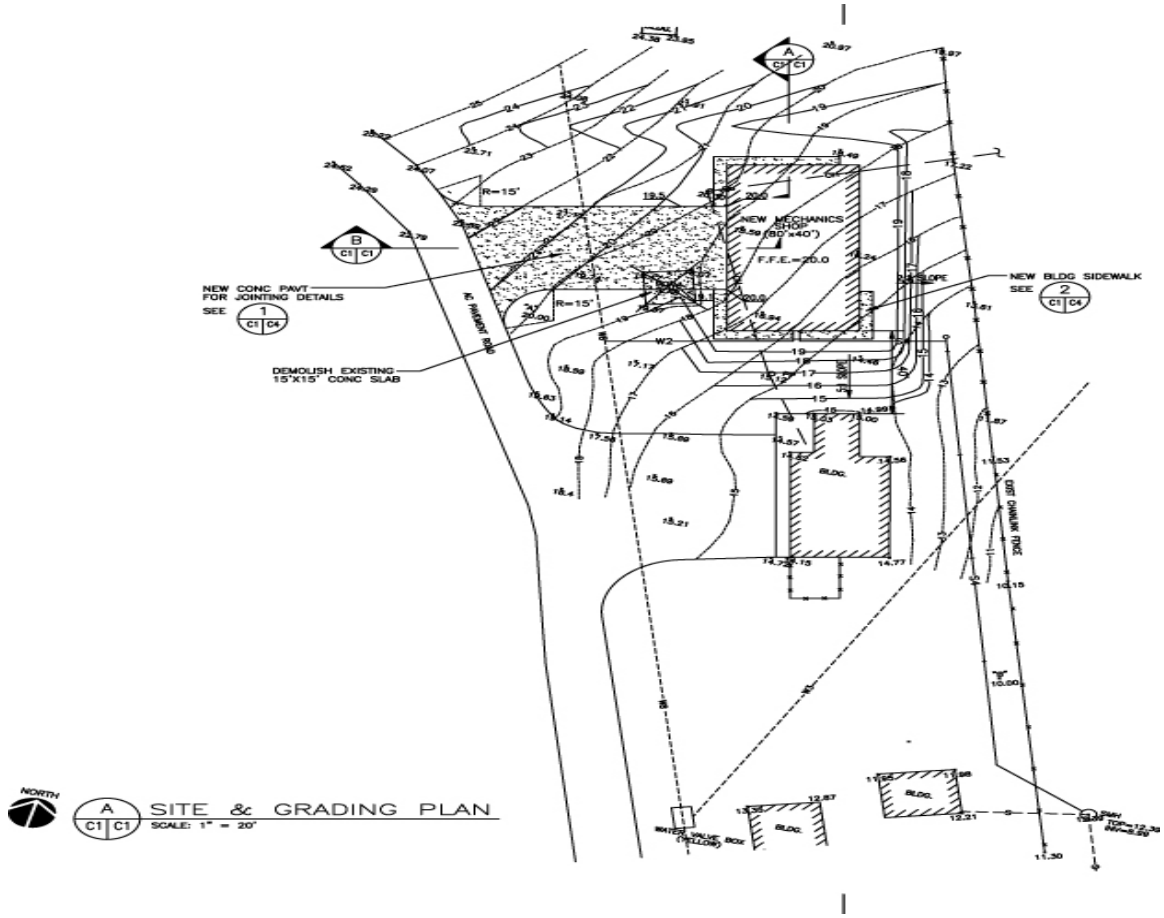


Figure 3-25 − Plot plan including "Director's Quarters" project.

Figure 3-26 shows another type of plot plan. In view A are five buildings to be supplied with electricity for power and lighting. An electrical layout has been superimposed on the plot plan General notes (*Figure 3-26*, view B); one detail (*Figure 3-26*, view C) and section A-A (*Figure 3-26*, view D) of that detail are shown The dotted line at the bottom of the page indicates underground ducts containing previously laid cable.

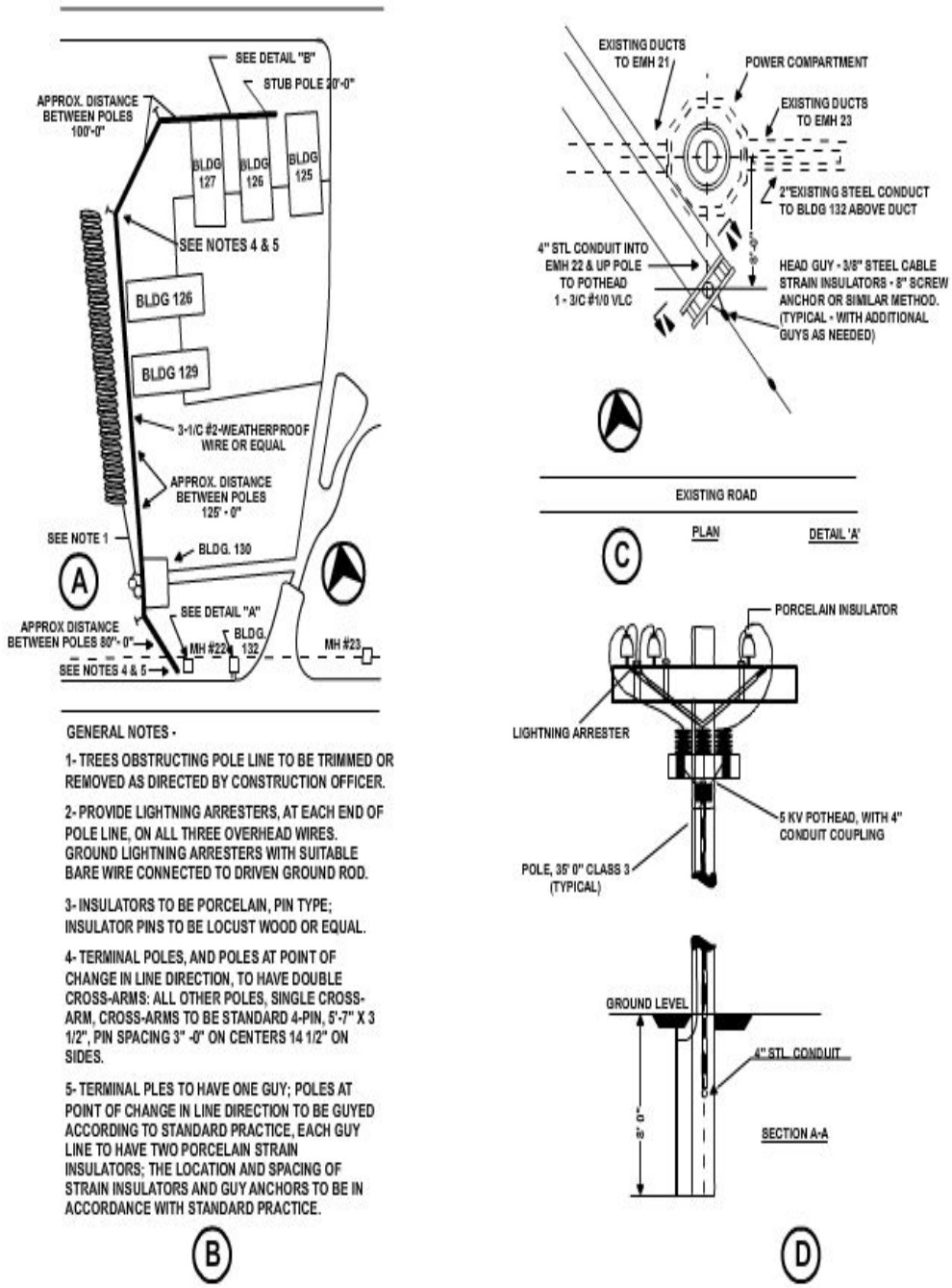


Figure 3-26 − Plot plan with electrical layout, general notes, detail, and section drawings.

The design engineer has decided to tap the cable at manhole 22 and run lines overhead to dead-end at the rear of building 126. *Figure 3-26*, view C, shows that lines are to be run underground from manhole 22 to the first pole crossarms. At building 126, lines are to be carried down the pole, regathered through a pothead into the conduit again, and run underground to a concrete slab, and out through another pothead to a transformer bank. Where do you get this information? Refer to *Figure 3-27*.

Figure 3-27 shows detail B that is indicated in *Figure 3-26*, view A. This represents the installation behind building 126 where the overhead line terminates. The last pole in the system is shown in the lower left comer. From the pole to the transformer bank, the underground conduit is indicated by dotted lines. The conduit runs underground to the concrete slab on which the transformers rest. Section A-A gives construction details of the slab.

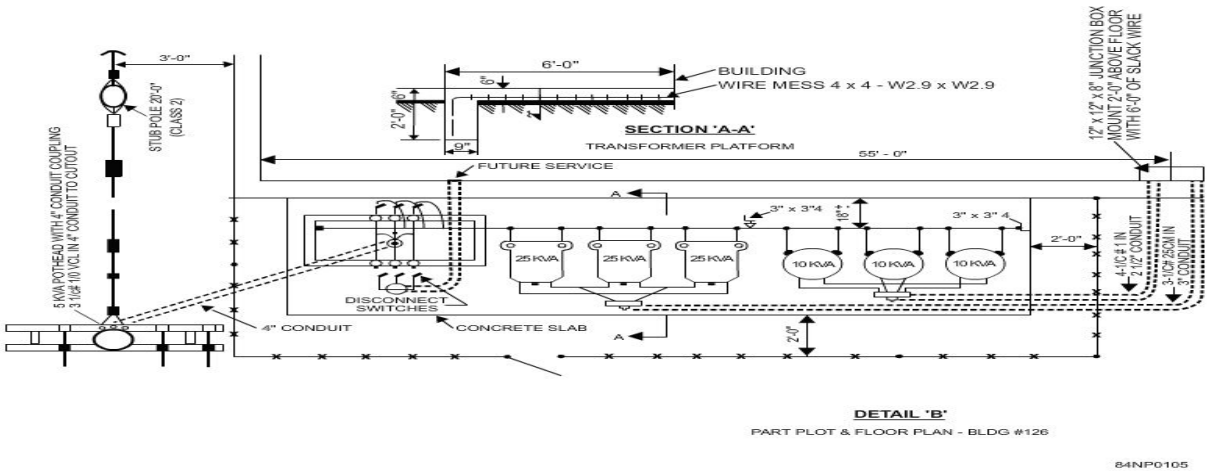


Figure 3-27 − Detail B indicated in Figure 3-26.

6.2.2.2 Floor Plans

Imagine that you want to know the outline of a building, such as the one shown in *Figure 3-28*, view A, including each partition, and you are equipped with a huge saw. If you sawed the building in half horizontally and looked down on it from above, you would see the complete outline of the building (view B). This particular view directly above

Figure 3-28 − Floor plan development.

would be called a floor plan (view C). Architects and engineers project their thoughts of a building, not yet built, onto a piece of paper and call it a floor plan. It does not matter

that the heights of the outlets, appliances, or building parts are different. These heights will be indicated by figures in inches or feet, next to the symbols that represent them. Electrical construction drawings are floor plans modified by the inclusion of electrical symbols.

Figure 3-29 shows an electrical layout superimposed on an outline taken from an architectural floor plan. The service line that brings power into the house is a three-wire line in 1 1/4-inch conduit. The service line feeds power by way of a service switch to alighting panel, from which three branch circuits run to the lighting fixtures and convenience outlets in the rooms. The symbols for these fixtures and outlets and the service switch are shown at the bottom of *Figure 3-29.*

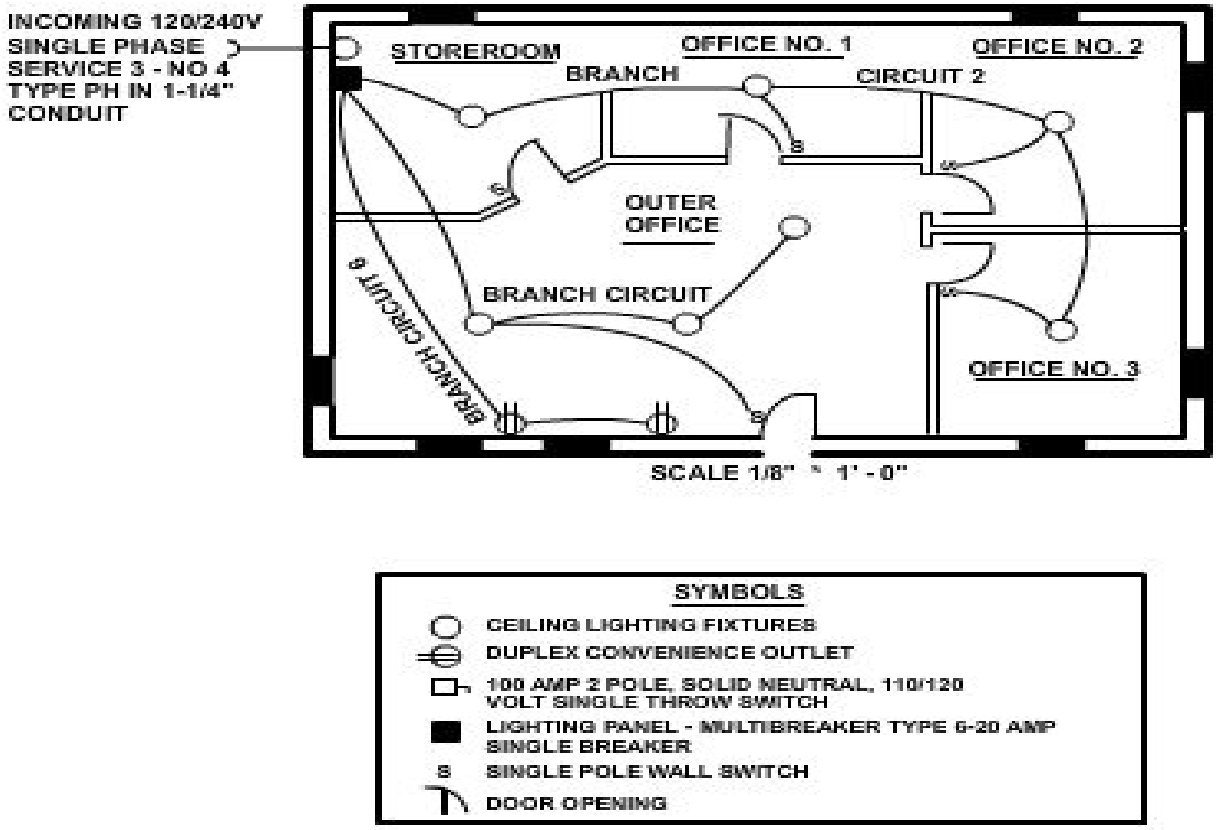


Figure 3-29 − Electrical floor plan layout.

6.3.0 Elevations

An elevation is a drawing that represents a view of the finished structure as you would see it from the front, back, left, or right. There are interior elevations, such as a view of a fireplace, as well as exterior elevations, as shown in the elevations of a small building shown in *Figure 3-30*.

Elevations show doors, windows, shapes of roof, chimneys, and exterior materials. These views provide the viewer with a finished appearance.

Elevations give few dimensions. An elevation view generally includes only those vertical dimensions that cannot be shown on the plan. A Construction Electrician can quickly see from any one of the elevations in *Figure 3-30* that there is an attic which would provide easy access to electrical wiring. This is important where there is a requirement for junction boxes that must be accessible. The electrician can also see a foundation wall where, if a service lateral is required, a conduit or sleeve must be placed (for a later run of conduit). This knowledge will allow the electrician to plan ahead to work with the Builders when they build the forms. The conduit will be placed in or through the form before the concrete is poured.

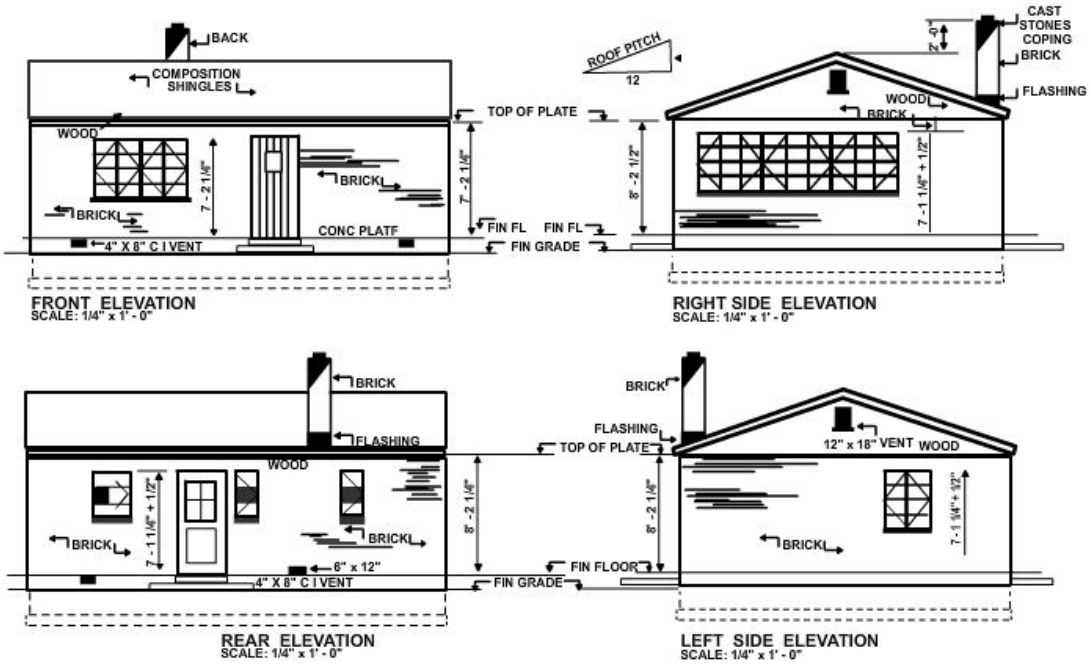


Figure 3-30 − Elevations.

6.4.0 Mechanical Drawings

Mechanical drawings include all drawings and notes that have to do with water supply, sewage, drainage, heating and ventilating, refrigeration, air conditioning, and gas supply systems. It may also include other drawings necessary to present the system properly in relation to the other portions of the project.

6.5.0 Shop Drawings

Shop drawings are drawings and related data used to show some portion of the work prepared by the construction contractor, manufacturer, distributor, or supplier. Product data, such as brochures, illustrations, standard schedules, performance charts, and other information, are furnished by the contractor or the manufacturer to show a material, product, or system for some portion of the work. Engineering Aids are sometimes required to draft shop drawings for minor shop and field projects. These

drawings may include shop items, such as doors, cabinets, and small portable buildings (prefabricated berthing quarters and modifications of existing structures), or they may come from portions of design drawings, specifications, or freehand sketches given by the design engineer. Working from a shop drawing is much like working from other working drawings. You convert the ideas you get from your interpretation of the lines and symbols into the product represented by the drawing.

6.6.0 Electrical Diagrams

In addition to the construction drawings discussed above, you will be working with other types of electrical drawings or diagrams. These drawings show the arrangement and relationship of parts. Electrical diagrams are usually used to show how the parts of one or more pieces of equipment are wired together. There are several types of these diagrams. They are similar, yet different in some way. The short description of each that follows should enable you to recognize their differences.

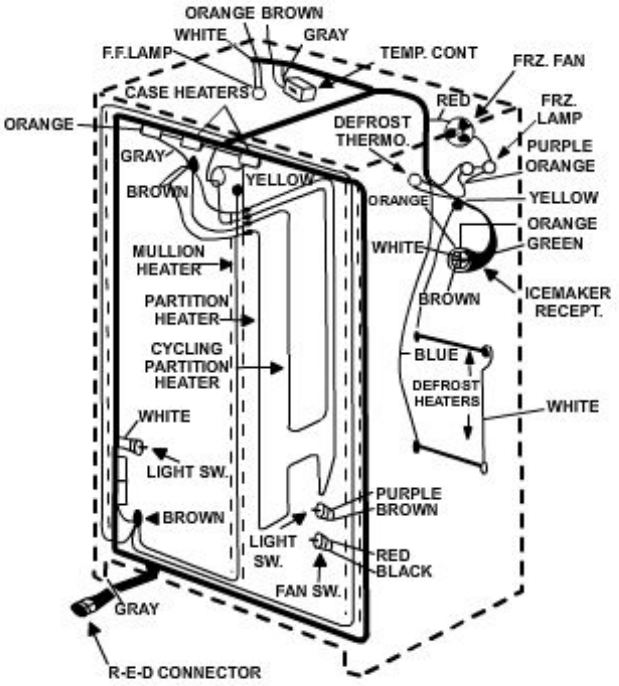


Figure 3-31 − Isometric wiring diagram.

6.6.1 Isometric Diagram

The isometric diagram is not often seen in electrical work. It may be used to show the electrical wiring system in multilevel buildings. Appliances sometimes have an isometric diagram glued to an access panel so that it may be referred to for a quick look at an entire wiring system. (See *Figure 3-31*.)

6.6.2 Block Diagram

A block diagram is a simple drawing showing the relationships of major parts of a wiring circuit or system. *Figure 3-32* shows a block diagram of a motor control system. You can easily see how it gets its name.

Sometimes the blocks are connected by only one line that may represent one or more conductors or cables. Blocks may represent major or minor components or parts. This type

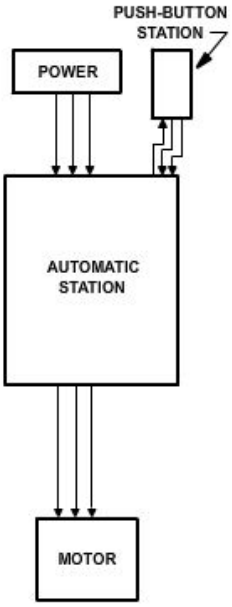


Figure 3-32 − Block diagram.

of diagram is often used to show something of the relationship of components in a power distribution system. The block diagram provides little help in troubleshooting.

6.6.3 Wiring Diagram

The wiring diagram is almost a picture drawing. It shows the wiring between components and the relative position of the components. *Figure 3-33* shows a wiring diagram of the same motor control system represented by the block diagram in *Figure 3-32*. In the wiring diagram, components are shown much as they would appear in a picture. The lines representing wires are marked with numbers or letter-number combinations. Lines L1, L2, and L3 are incoming power leads. The diagram shows which terminals these power leads are connected to in the motor starter. Leads connected to terminals T1, T2, and T3 are the motor leads.

The numbers without letters mark the control terminals of the starter. Wiring diagrams are often used along with a list of repair parts. Wiring diagrams may be of some help in troubleshooting circuit problems.

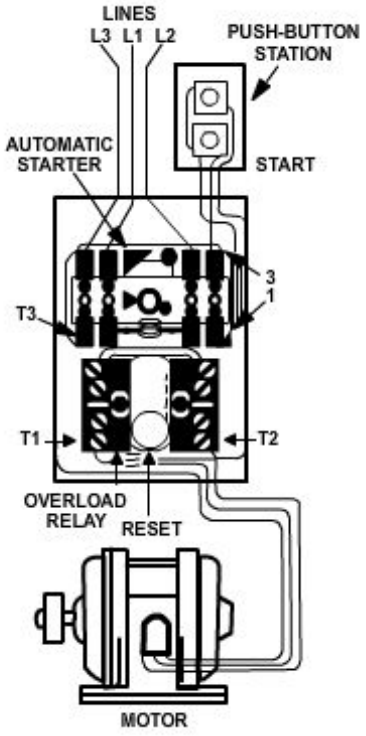


Figure 3-33 − Wiring diagram.

6.6.4 Connection Diagram

Figure 3-34 is a connection diagram. By comparing the symbols from this diagram to those in *Figure 3-2*, you can see that graphic symbols represent parts or components in the connection diagram. The connection diagram in *Figure 3-34* is a combination of basic symbols (like the open-contact symbol). You can see how the controller pictured in *Figure 3-33* works internally.

The connection diagram shows all the internal and external connections. The circuitry can be traced more easily on it than on the wiring diagram. The

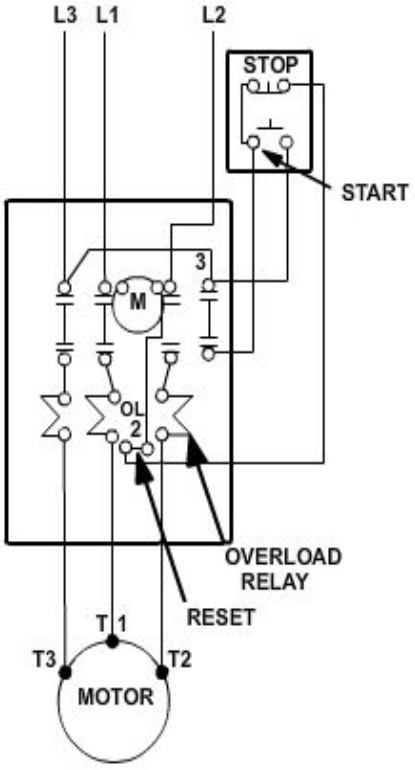


Figure 3-34 – Connection diagram.

components are still shown in their relative positions. You can use this diagram to help you connect all the wiring and trace any part of the circuit. The connection diagram is a valuable troubleshooting tool. This type of diagram is often found inside the access cover of a piece of equipment.

6.6.5 Schematic Diagram

The schematic or elementary diagram (*Figure 3-35*) is a drawing that shows the electrical connections and functions of a specific circuit arrangement. It facilitates tracing the circuit and its functions without regard to the physical size, shape, or relative position of the component device or parts. The schematic diagram, like the connection diagram, makes use of symbols instead of pictures. *Figure 3-35* shows, by a schematic diagram, the same motor control system shown in *Figures 3-32*, *3-33*, and *3-34*. This diagram is laid out in a way that makes the operation of the components easy to understand. This type of schematic diagram with the components laid out in a line is sometimes called a one line or single-line diagram.

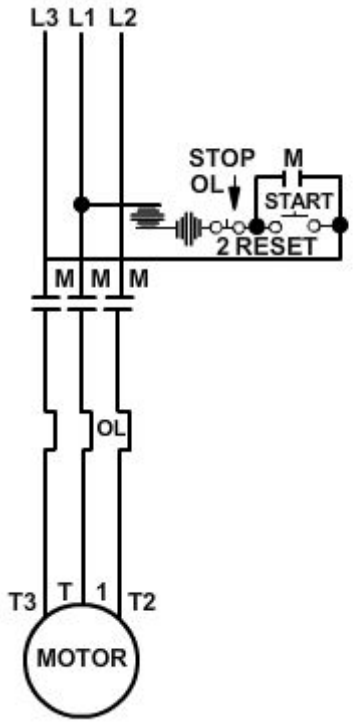


Figure 3-35 − Schematic diagram.

Most schematic diagrams are more complicated than the one shown in *Figure 3-35*. The more complicated ones can be broken down into one line diagrams, circuit by circuit. You can draw (or freehand sketch) your own one line diagram by tracing only one circuit, component by component, through a multicircuit schematic, using the symbols in *Figure 3-2*. Circuits "A" and "B" in *Figure 3-36* show only the control circuit from *Figure 3-34* laid out in one-line form. From these simple circuits, it is easy to see that as soon as the start button is pushed, the “M” coil (operating coil of the motor controller) will be

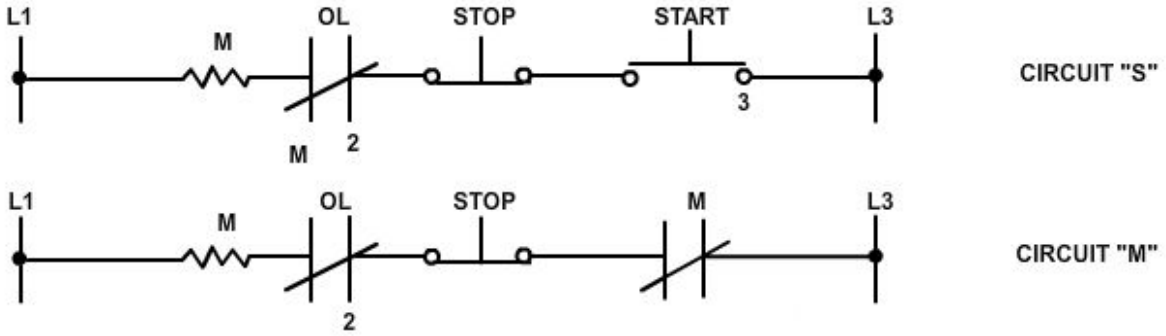


Figure 3-36 − One line diagram of a motor control circuit.

energized. The operating coil is now held closed through the "M" contacts.

Your own freehand sketches can help you understand other types of diagrams as well as the schematic. You may vary these sketches to suit your needs. You may draw a one-line diagram, using symbols, from a wiring diagram, an isometric diagram, or a connection diagram, as long as all the necessary details are there for you to convert to lines and symbols.

Summary

Your use of blueprints and plans is an integral part of each day on a construction project. You need solid blueprint, floor, and plot plan reading skills on the job, whether you’re cutting wood, applying paint to a wall, or installing wiring. All above skills are critical for any construction crewmember.

Review Questions (Select the Correct Response)

1. Labor required to support construction operations but does not, in itself, produce an end product is known as what?

   A. Indirect Labor
   B. Direct Labor
   C. Planning Labor
   D. Construction Labor

2. Which of the following estimates is used to provide the basis for material deliveries?

   A. Equipment Estimates
   B. Manpower Estimates
   C. Activity Estimates
   D. Material Estimates

3. Labor expended directly on assigned construction tasks is known as what type of labor?

   A. Indirect Labor
   B. Direct Labor
   C. Planning Labor
   D. Construction Labor

4. Which of the following pieces of documentation contains the vendor's name for equipment used on a construction project?

   A. Activity Report
   B. Equipment Guide List
   C. Master Planning Document
   D. Bill of Material

5. Which of the following estimates is used to provide direct labor man-days?

   A Equipment Estimates
   B. Manpower Estimates
   C. Activity Estimates
   D. Material Estimates

6. Which of the following estimates is used to provide a description of material to be used on a construction project?

   A. Equipment Estimates
   B. Manpower Estimates
   C. Activity Estimates
   D. Material Estimates

7. Process of determing when an action must be taken is also known as what?

   A. Planning
   B. Scheduling
   C. Estimating
   D. Labor

8. When inconsistencies are found between drawings and specifications, which document takes precedence?

   A. Drawings
   B. Blueprints
   C. Specifications
   D. Floor Plan

9. A building project is divided into how many phases?

   A. 2
   B. 4
   C. 6
   D. 8

10. Which of the following is developed in the first phase of a building project?

   A. Preliminary Drawings
   B. Shop Drawings
   C. Presentation Drawings
   D. Working Drawings

11. When are working drawings developed?

   A. First Phase
   B. Second Phase
   C. Third Phase
   D. Fourth Phase

12. Which of the following is NOT a source of information during the estimating phase of a project?

   A. Construction Drawings
   B. Specifications
   C. Bill of Materials
   D. Activity Report

13. How many categories of drawings can be indexed on construction drawings?

   A. 4
   B. 6
   C. 8
   D. 10

14. When are as-built drawings necessary?

    A. To illustrate a specific task
    B. To illustrate construction deviations
    C. To illustrate plot elevations
    D. To illustrate power pole locations

15. Which of the following is defined as a heavy, continuous line that outlines or borders the drawing?

    A. Trim Line
    B. Border Line
    C. Dimension Line
    D. Main object Line

16. Which of the following is defined as a light line drawing outside the structure to show the distance between two points?

    A. Dimension Line
    B. Trim Line
    C. Main object Line
    D. Border Line

17. Which of the following defines a light, continuous line along which the tracing is trimmed to square the sheet?

    A. Dimension Line
    B. Border Line
    C. Trim Line
    D. Main Object Line

18. Which of the following defines a heavy, unbroken line used to show visible edges that would be seen by individuals looking at the house?

    A. Dimension Line
    B. Border Line
    C. Trim Line
    D. Main Object Line

19. **(True or False)** Equipment Line is defined as a light, continuous, unbroken line used to show the location of equipment.

    A. True
    B. False

20. Which type of line is used to indicate edges hidden under part of the structure?

    A. Section Line
    B. Invisible Line
    C. Broken Line
    D. Extension Line

21. Which of the following lines use an arrowhead to indicate direction of a staircase?

A. Section Line
B. Broken Line
C. Stair Indicator Line
D. Equipment Line

22. Which of the following is defined as a thin solid ruled line with freehand zigzags used to reduce the size of a drawing?

A. Broken Line
B. Center Line
C. Extension Line
D. Break Line

23. **(True or False)** Schedules are systematic method of presenting information in a block format.

A. True
B. False

24. By using the following scale (1/4" = 1'0"), if a wall depicted in a drawing measures 4 1/2", what is the actual length of the wall?

A. 17 Feet
B. 18 Feet
C. 19 Feet
D. 20 Feet

25. How many scales are located on an architect's scale?

A. 7
B. 9
C. 11
D. 13

26. How long is meter in inches?

A. 19.37 inches
B. 25.37 inches
C. 32.56 inches
D. 39.37 inches

27. How many parts are there to a blueprint?

A. 2
B. 4
C. 6
D. 8

28. The signature of the approving authority is located in which part of a blueprint?

A. Title Block
B. Revision Block
C. Legend
D. Bill of Material

29. While reviewing a set of blueprints, you notice a sheet designation letter of “C”. What does this letter represent?

A. Cost
B. Civil
C. Concrete Type
D. Code

30. Drawing number is located in what position on a blueprint?

A. Upper right hand corner
B. Lower left hand corner
C. Lower right hand corner
D. Upper left hand corner

31. Revision number is located in what position on a blueprint?

A. Upper left hand corner
B. Lower right hand corner
C. Lower left hand corner
D. Upper right hand corner

32. Which of the following parts of a blueprint contains a list of materials needed for the job depicted on print?

A. Bill of Material
B. Legend
C. Title Block
D. Revision Block

33. Which of the following plans contain tree locations for a job site?

A. Architectural
B. Civil
C. Structural
D. Electrical

34. Which of the following delineates a door schedule?

A. Civil Plans
B. Structural Plans
C. Architectural Plans
D. Mechanical Plans

35. Which set of plans would contain interior wiring drawings?

A. Mechanical
B. Civil
C. Architectural
D. Electrical

36. Which type of drawing is a combination of a floor plan and elevation drawing?

A. Isometric
B. Working
C. Wiring
D. Plumbing

37. Horizontal lines in an orthographic elevation are projected at what angle?

A. 10°
B. 30°
C. 75°
D. 90°

38. Which of the following commands sets forth the standards of construction for the NCF?

A. NAVSEA
B. NAVSYSCOM
C. NAVFACENGCOM
D. CECOS

39. How many divisions are associated with project specifications?

A. 11
B. 13
C. 15
D. 17

40. Which one of the following is NOT a division of project specifications?

A. Cost
B. Masonry
C. Finishes
D. Moisture Control

41. Which of the following provide a means of coordination between the different ratings?

A. Architectural Drawings
B. Working Drawings
C. Electrical Schematics
D. Plot plans

42. Which of the following plans will show the slope of the land prior to construction?

A. Architectural
B. Civil
C. Plot
D. Mechanical

43. **(True or False)** Elevation drawings represent a view of a finished structure from the front.

A. True
B. False

44. Which of the following is defined as a simple drawing showing the relationship of major parts of a wiring circuit?

A. Isometric Diagram
B. Connection Diagram
C. Block Diagram
D. Wiring Diagram

45. Which of the following shows the wiring between components and the relative position of the components?

A. Isometric Diagram
B. Connection Diagram
C. Block Diagram
D. Wiring Diagram

46. Which of the following is a drawing that shows the electrical connections?

A. Schematic Diagram
B. Connection Diagram
C. Wiring Diagram
D. Block Diagram

Trade Terms Introduced in this Chapter

Blueprint Reading	Interpreting the ideas expressed by others on drawing whether the drawings are actually blueprints or not
Chamfer	To cut a furrow in (as a column)
Presentation Drawings	Show the proposed building or facility in an attractive setting in its natural surroundings at the proposed site
Shop Drawings	Supplied by manufacturers to show fabrication of building parts

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Blueprint Reading and Sketching, NAVEDTRA 12014, Naval Education and Training Program Management Support Activity*, Pensacola, FL, 1994.

Graphic Symbols for Electrical and Electronics Diagrams, American National Standard, ANSI 2.2-1975, The Institute of Electrical and Electronics Engineers, NY, 1986.

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Policy and Procedures for Project Drawing and Specification Preparation MILHDBK-1006/1A, Chesapeake Division, Naval Facilities Engineering Command, Washington DC, 1995.

Putnam, Robert, *Construction Blueprint Reading,* Englewood Cliffs, NJ, 1985.

U.S. Metric Association: http://lamar.colostate.edu/~hillger/

Tools and Their Uses. NAVEDTRA 14256. June 1992.

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