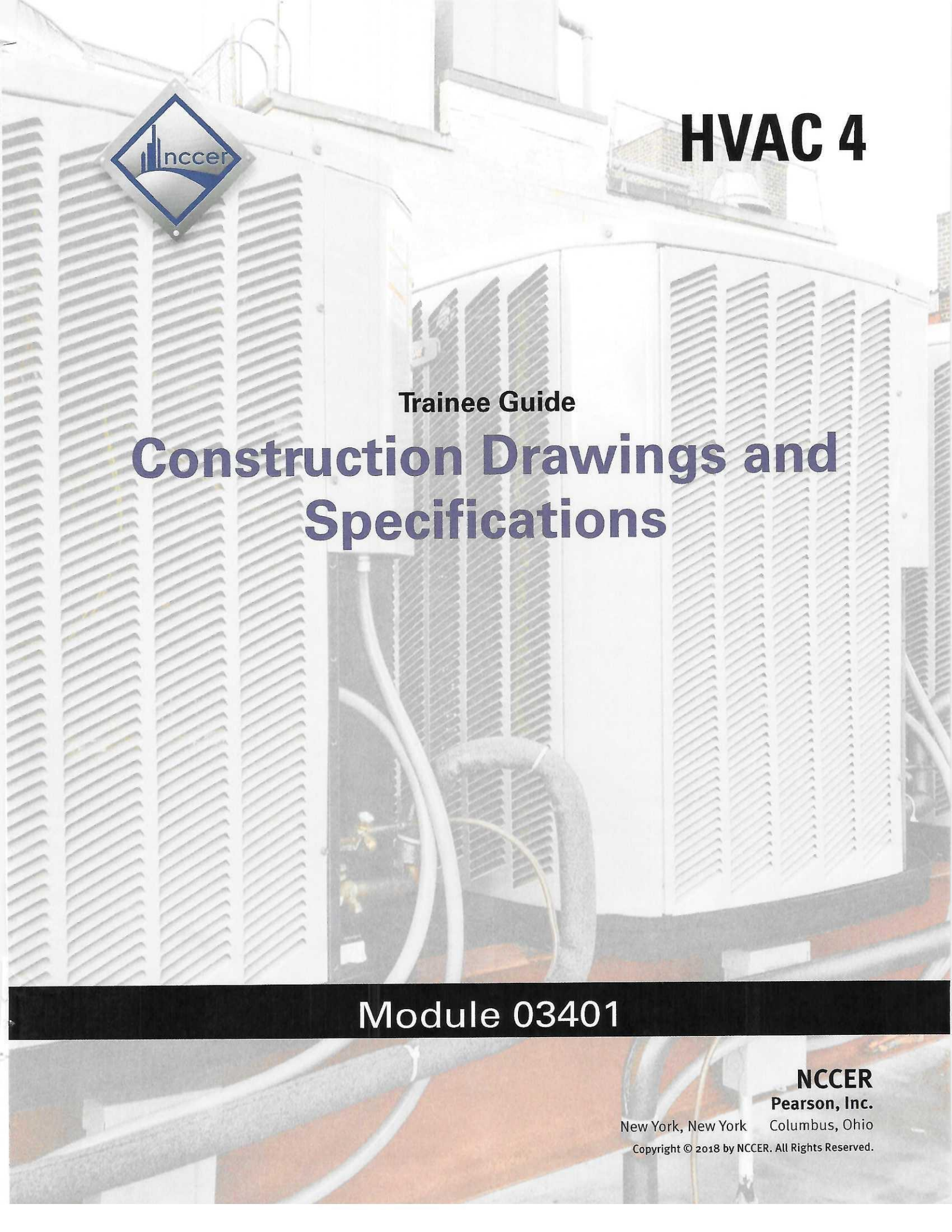


HVAC 4

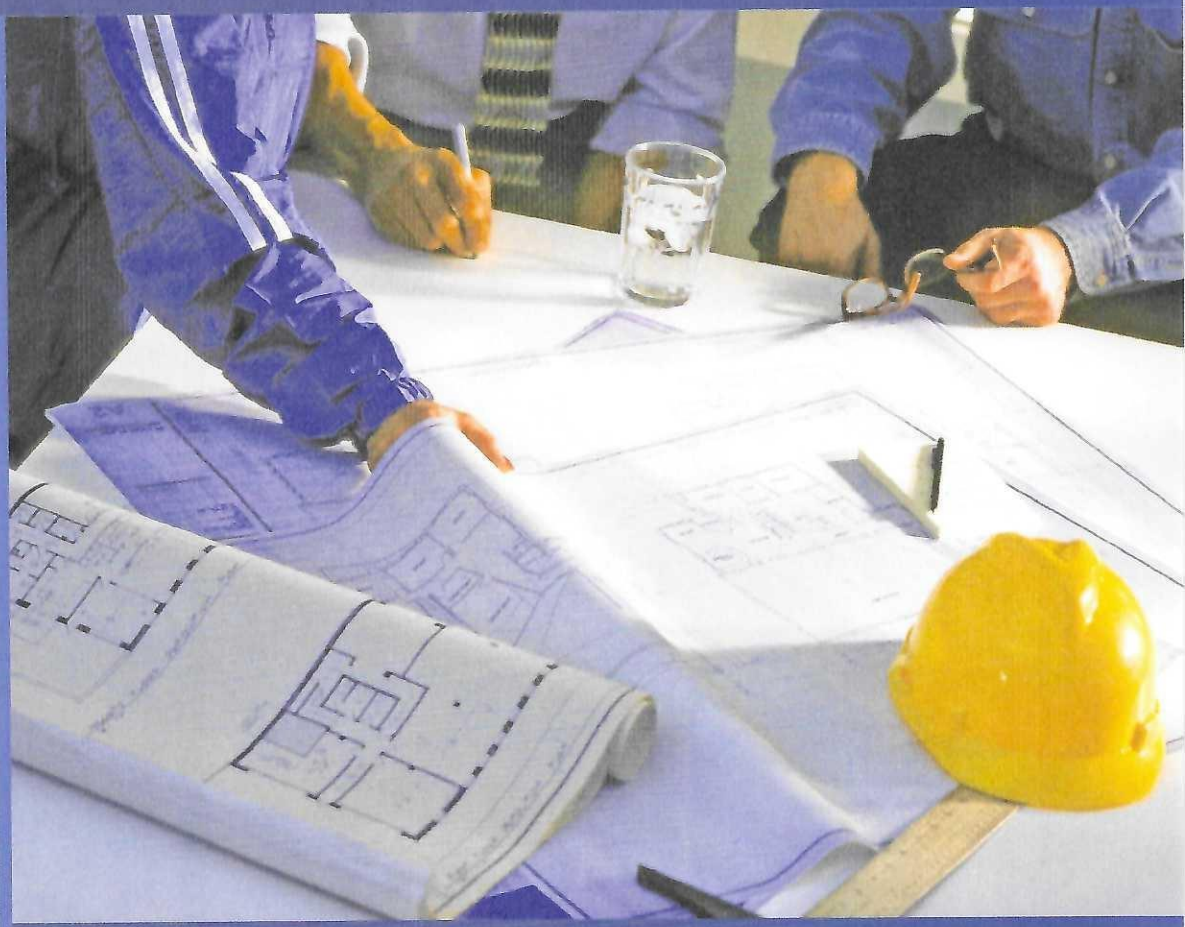
Trainee Guide

Construction Drawings and Specifications

Module 03401

NCCER
Pearson, Inc.
New York, New York Columbus, Ohio

Construction Drawings and Specifications



Overview

Anyone involved in the installation of heating and cooling equipment for new construction must be able to interpret the project drawings and specifications. The drawings show the locations of equipment, duct runs, piping runs, and electrical wiring. During the estimating and planning processes, the drawings are used to determine the amount and types of equipment, accessories, and materials needed for the job. Correct interpretation of the drawings is essential in order to determine the correct price for the job, and to have the correct amounts and types of equipment and materials available. A technician or installer who does not learn to interpret them properly is unlikely to advance very far in his or her career.

Module 03401

Trainees with successful module completions may be eligible for credentialing through NCCER's National Registry. To learn more, go to **www.nccer.org** or contact us at **1.888.622.3720**. Our website has information on the latest product releases and training, as well as online versions of our *Cornerstone* magazine and Pearson's product catalog.

Your feedback is welcome. You may email your comments to **curriculum@nccer.org,** send general comments and inquiries to **info@nccer.org**, or fill in the User Update form at the back of this module.

This information is general in nature and intended for training purposes only. Actual performance of activities described in this manual requires compliance with all applicable operating, service, maintenance, and safety procedures under the direction of qualified personnel. References in this manual to patented or proprietary devices do not constitute a recommendation of their use.

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03401
Construction Drawings and Specifications

Objectives

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

1. Describe the types of drawings HVAC technicians work with and how they are used.
   a. Explain the initial approach to viewing a set of drawings.
   b. Describe site plans and their purpose.
   c. Describe plan views, elevations, detail drawings, and section drawings and their purposes.
   d. Describe plumbing, mechanical, and electrical drawings and their purposes.
   e. Describe shop drawings and their purpose.
   f. Describe as-built drawings and their purpose.
   g. Describe schedules and their purpose.
   h. Describe the Request for Information (RFI) and how it is prepared.
   i. Explain the importance of building codes to the design process.
2. Describe the uses of specifications and submittals in construction projects.
   a. Describe specifications and their purpose.
   b. Describe submittals and their purpose.
3. Describe the takeoff process and how it is performed.
   a. Identify and describe the tools and materials used in the takeoff process.
   b. Explain how to conduct a takeoff.

Performance Tasks

Under the supervision of your instructor, you should be able to do the following:

1. Identify and interpret the following on an architectural drawing:
   - Floor plans and details
   - Elevations
   - Foundation plan
   - Reflected ceiling plan
2. Identify and interpret at least four of the following on a plumbing plan drawing:
   - Sanitary plumbing plans
   - Domestic water plumbing plans
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
3. Identify and interpret the following on a mechanical plan drawing:
   - Hot- and chilled-water coil piping
   - HVAC piping
   - Chiller piping/installation
   - Refrigeration piping schematics
   - Air handling unit installation/connecting ductwork
   - Hot- and chilled-water flow diagrams
   - Schedules
   - Specification references
   - Legends

4. Identify and interpret the following on an electrical plan drawing:
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
5. Interpret HVAC-related shop drawings.
6. Perform an HVAC equipment and material takeoff and prepare the takeoff forms.

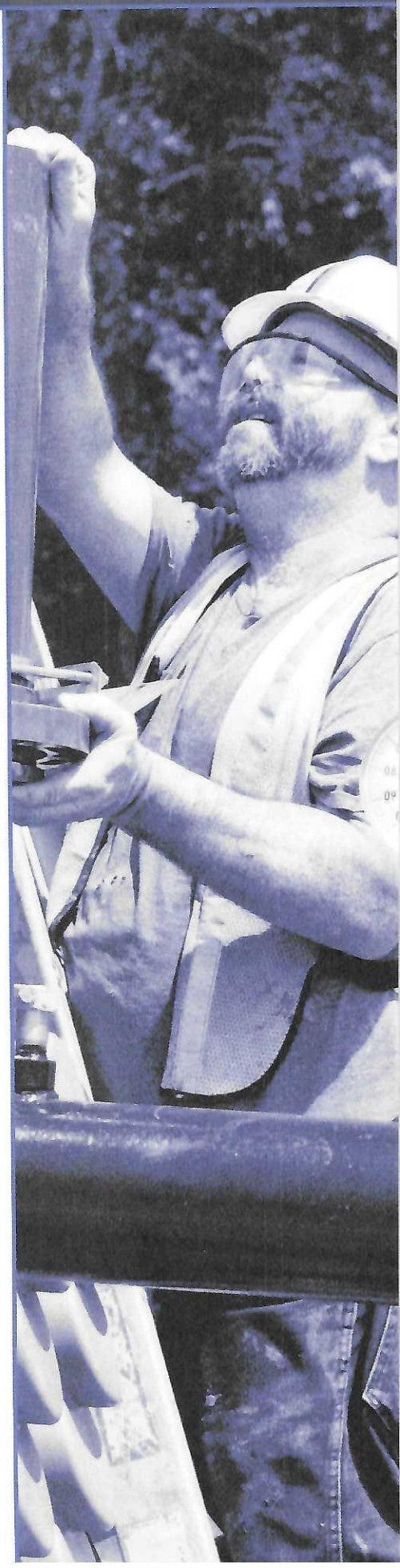
Trade Terms

Change order
Coordination drawing
Cut list
Detail drawing
Elevation view
Floor plan
Longitudinal section
Plan view
Riser diagram
Schedules
Section drawing
Shop drawing
Site plan
Takeoff
Transverse section

Industry-Recognized Credentials

If you are training through an NCCER-accredited sponsor, you may be eligible for credentials from NCCER's Registry. The ID number for this module is 03401. Note that this module may have been used in other NCCER curricula and may apply to other level completions. Contact NCCER's Registry at 888.622.3720 or go to **www.nccer.org** for more information.

Contents



Figures

SECTION ONE

1.0.0 HVAC DRAWING TYPES

Objectives

Describe the types of drawings HVAC technicians work with and how they are used.

a. Explain the initial approach to viewing a set of drawings.
b. Describe site plans and their purpose.
c. Describe plan views, elevations, detail drawings, and section drawings and their purposes.
d. Describe plumbing, mechanical, and electrical drawings and their purposes.
e. Describe shop drawings and their purpose.
f. Describe as-built drawings and their purpose.
g. Describe schedules and their purpose.
h. Describe the Request for Information (RFI) and how it is prepared.
i. Explain the importance of building codes to the design process.

Performance Tasks

1. Identify and interpret the following on an architectural drawing:
   - Floor plans and details
   - Elevations
   - Foundation plan
   - Reflected ceiling plan
2. Identify and interpret at least four of the following on a plumbing plan drawing:
   - Sanitary plumbing plans
   - Domestic water plumbing plans
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
3. Identify and interpret the following on a mechanical plan drawing:
   - Hot- and chilled-water coil piping
   - HVAC piping
   - Chiller piping/installation
   - Refrigeration piping schematics
   - Air handling unit installation/connecting ductwork
   - Hot- and chilled-water flow diagrams
   - Schedules
   - Specification references
   - Legends
4. Identify and interpret the following on an electrical plan drawing:
   - Riser diagrams
   - Schedules
   - Specification references
   - Legends
5. Interpret HVAC-related shop drawings.

Trade Terms

Coordination drawings: Elevation, location, and other drawings produced for a project by the individual contractors for each trade to prevent a conflict between the trades regarding the installation of their materials and equipment. Development of these drawings evolves through a series of review and coordination meetings held by the various contractors.

Cut list: An information sheet that is derived from shop drawings. It is the shop guide for fabricating duct runs and fittings.

Detail drawing: A drawing of a feature that provides more elaborate information than is available on a plan.

Elevation view: A view that depicts a vertical side of a building, usually designated by the direction that side is facing; for example, right, left, east, or west elevation.

Floor plan: A building drawing indicating a plan view of a horizontal section at some distance above the floor, usually midway between the ceiling and the floor.

Longitudinal section: A section drawing in which the cut is made along the long dimension of the building.

Plan view: The overhead view of an object or structure.

Riser diagram: A one-line schematic depicting the layout, components, and connections of a piping system or electrical system.

Schedules: Tables that describe and specify the types and sizes of items required for the construction of a building.

Section drawing: A drawing that depicts a feature of a building as if there were a cut made through the middle of it.

Shop drawing: A drawing that indicates how to fabricate and install individual components of a construction project. A shop drawing may be drafted from the construction drawings of a project or provided by the manufacturer.

Site plan: A construction drawing that indicates the location of a building on a land site.

Transverse section: A section drawing in which the "cut" is made along the short dimension of the building.

This module reviews and builds on the information previously studied in the Core Curriculum module *Introduction to Construction Drawings*. It focuses on techniques for reading various types of HVAC-related construction drawings and project specifications. Construction drawings tell the HVAC technician and installer, as well as other skilled tradespeople, how to build a specific building or structure. A specification is a related contractual document used along with the construction drawings. It contains detailed written instructions that supplement the information shown in the set of drawings. As an HVAC technician, you must be able to interpret drawings and specifications correctly. Failure to do so may result in costly rework and unhappy customers. Depending on the severity of a mistake, it can also expose you and your employer to legal liability.

1.1.0 Viewing a Set of Drawings

The following general procedure is suggested as a method of reading a set of drawings. Use this procedure to familiarize yourself with an available set of drawings:

Step 1 Locate and read the title block. The title block tells you what the drawing is about. It contains critical information about the drawing such as the scale, date of last revision, drawing number, and architect or engineer. If you have to remove a sheet from a set of drawings, be sure to fold the sheet with the title block facing up.

Step 2 Find the North arrow. Always orient yourself to the structure. Knowing where North is enables you to more accurately describe the locations of walls and other parts of the building.

Step 3 Check the list of drawings in the set. Note the sequence of the various types of plans. Some drawings have an index on the front cover. Notice that the prints are broken into several categories, as shown in *Figure 1*. However, drawing sets do not have to contain all the categories of drawings shown.

Step 4 Study the **site plan** to observe the location of the building. Also notice that the geographic location of the building may be indicated on the site plan.

Step 5 Check the **floor plan** for the orientation of the building. Observe the location and other details of entries, corridors, offsets, and any special features.

Step 6 Study the features that extend for more than one floor, such as plumbing, vents, stairways, elevator shafts, heating and cooling ductwork, and piping. Determine the location of all main electrical runs and fire sprinkler system lines while looking for possible installation conflicts.

Step 7 Check the floor and wall construction and other details relating to exterior and interior walls.

Step 8 Check the foundation plan for size and types of footings, reinforcing steel, and loadbearing substructures.

Step 9 Study the mechanical plans for heating, cooling, and plumbing details.

Step 10 Observe the electrical entrance and distribution panels, as well as the installation of the lighting and power supplies for special equipment.

Step 11 Check the notes on the various pages and compare the specifications against the construction details. Look for any variations.

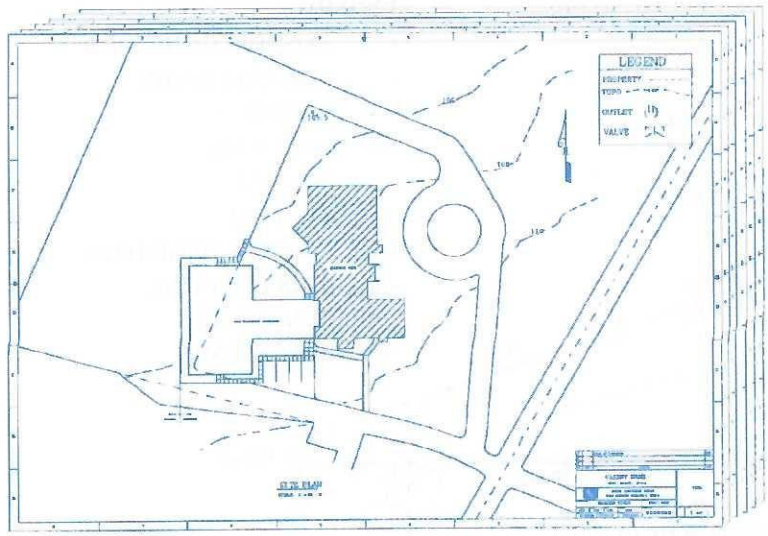
Did You Know?

Blueprints

The term *blueprint* is derived from a method of reproduction used in the past. A true blueprint shows the details of the structure as white lines on a blue background.

The method involved coating a paper with a specific chemical. After the coating dried, an original hand drawing was placed on top of the paper. Both papers were then covered with a piece of glass and set in the sunlight for about an hour. The coated paper was developed much like a photograph. After a cold-water wash, the coated paper turned blue and the lines from the drawing remained white.

Today, most drawing reproduction methods produce a black line on a white background. These copies or prints are typically made using a copying machine. However, the term *blueprint* is still widely used, but has been replaced with the terms *drawings* and *prints*.



TITLE SHEET(S)

ARCHITECTURAL DRAWINGS

- SITE (PLOT) PLAN
- FOUNDATION PLAN
- FLOOR PLANS
- INTERIOR/EXTERIOR ELEVATIONS
- SECTIONS
- DETAILS
- SCHEDULES

STRUCTURAL DRAWINGS

PLUMBING PLANS

MECHANICAL PLANS

ELECTRICAL PLANS

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Figure 1 Typical categories of drawings in a set of construction drawings.

Step 12 Thumb through the sheets of drawings until you are familiar with all the plans and structural details.

Step 13 Recognize applicable symbols and their relative locations in the plans (see *Appendix A* for a listing of common line types, symbols, and abbreviations). Note any special construction details or variations that will affect your trade.

1.2.0 Site Plans

The site plan, also called a plot plan, (*Figure 2*) indicates the location of the building on the land site. It may include topographic features such as contour lines, trees, and shrubs. It may also include some construction features such as walks, driveways, curbs, and gutters.

Often the roof plan, if there is one, is also shown on the site plan. General notes pertaining to grading and shrubbery may also be included on the site plan. A separate landscape plan may also exist.

On large commercial jobs, a utility site plan may also be included in the drawing set. It shows the locations for underground facilities such as gas and water pipelines, sanitary sewers, electric power or communication system cables, and other facilities.

1.3.0 Plans Views, Elevations, Detail, and Section Drawings

Several types of drawings—including exterior views, cut-aways, enlargements, and various forms of overhead views (**plan views**)—are used to show different structural aspects and perspectives of a building. Taken together, the drawings show the big picture of how the building is constructed and they provide details for special features such as fixtures and equipment.

1.3.1 Plan Views (Floor, Roof, and Ceiling Plans)

The floor plan (*Figure 3*) is one of the most important working drawings. It is the first drawing done by the designer. It shows the length and width of the building and the location of the rooms and other spaces that the building contains. Each floor of the structure has a different floor plan.

A floor plan is a plan view of a horizontal section taken at some distance above the floor, usually midway between the floor and ceiling. However, the cutting plane of the sectional drawing may be offset to a higher or lower level so that it cuts through the desired features such as windows and doors. The cut view crosses all openings for that floor or story. This view gives the dimensions of the window and door openings and indicates which way the doors are to swing.

When supplied, the contractor consults the roof plan for information pertaining to roof slope, roof drain placement, and other pertinent information regarding ornamental sheet metal work and gutter and downspout technical information. *Figure 4* shows an example of a typical roof plan. Where applicable, the roof plan may also contain information on the location of air conditioning units, exhaust fans, and other ventilation equipment.

Some drawing sets include a reflected ceiling plan (*Figure 5*). This view shows the ceiling as if

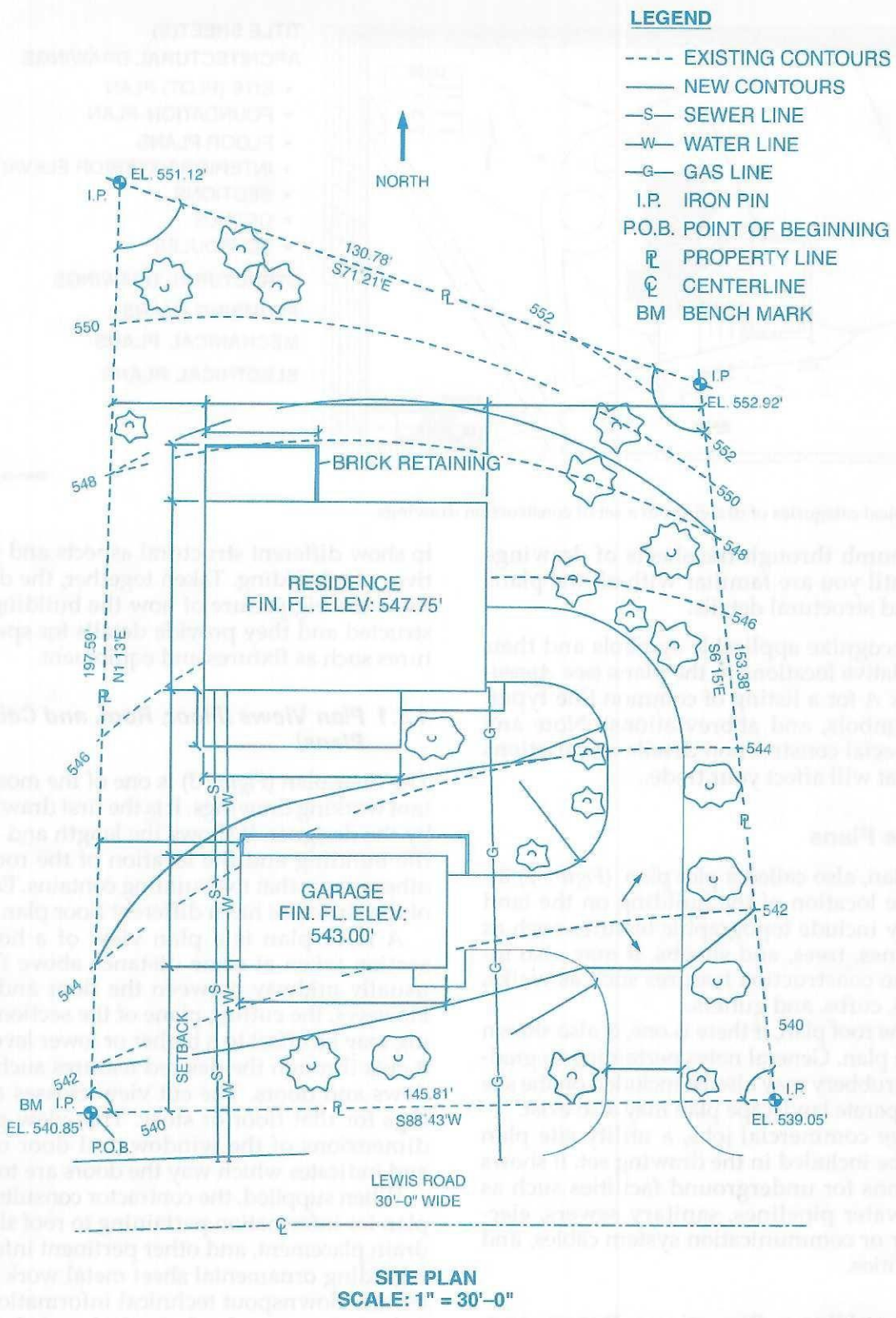
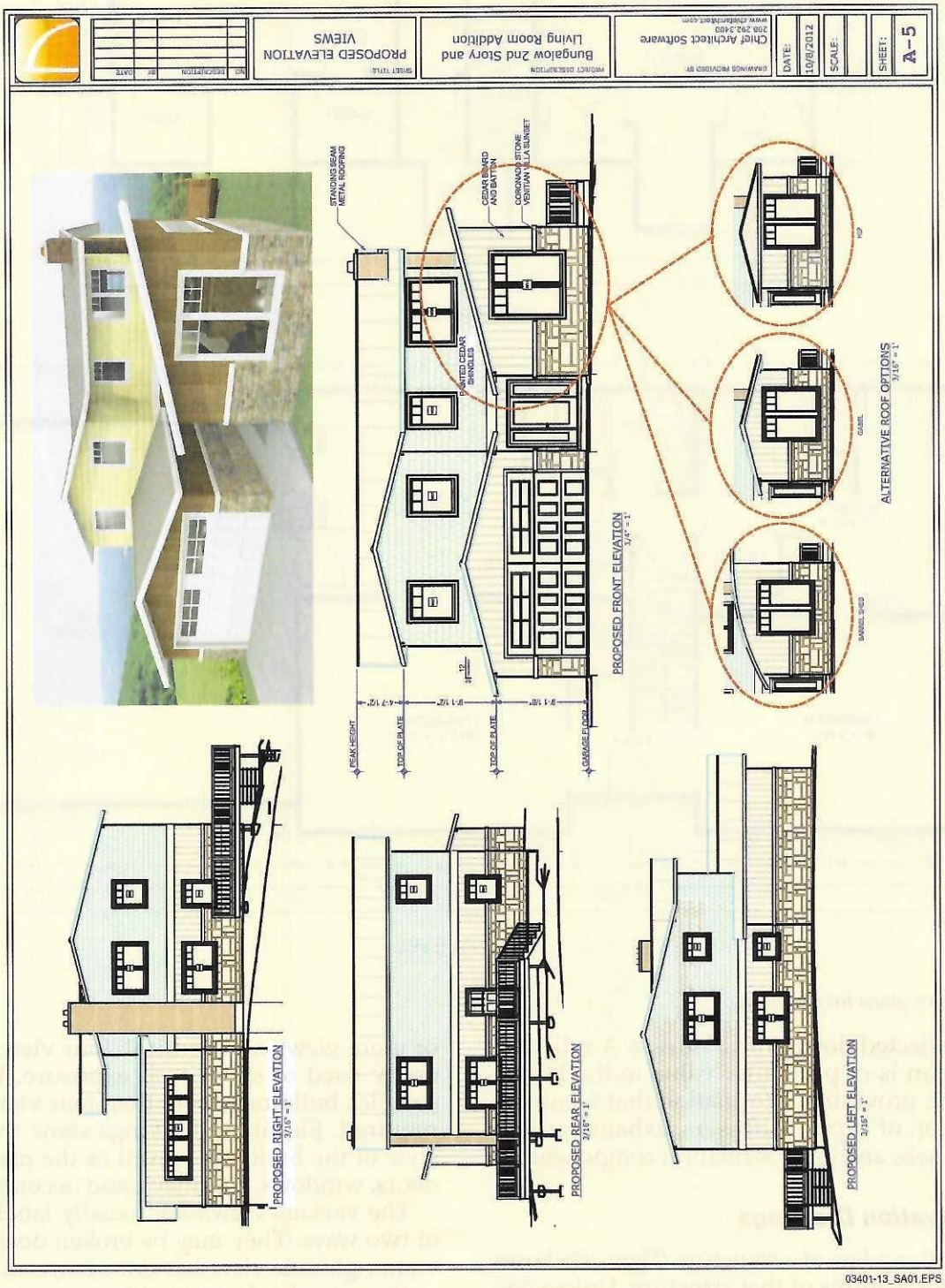


Figure 2 Site plan.

Architectural Plans

Architectural plans have been used over the centuries to pictorially describe buildings and structures before they are actually built. In the past, draftspersons would draw these plans by hand. Today, most drawings for buildings and other structures are generated by computer using a process called computer-aided design (CAD). Working with a variety of architectural software, the drafter creates the drawings for the building or structure electronically on the computer. Then, using a computer command, the electronic drawing files are sent to a printer or plotter to be output on paper.



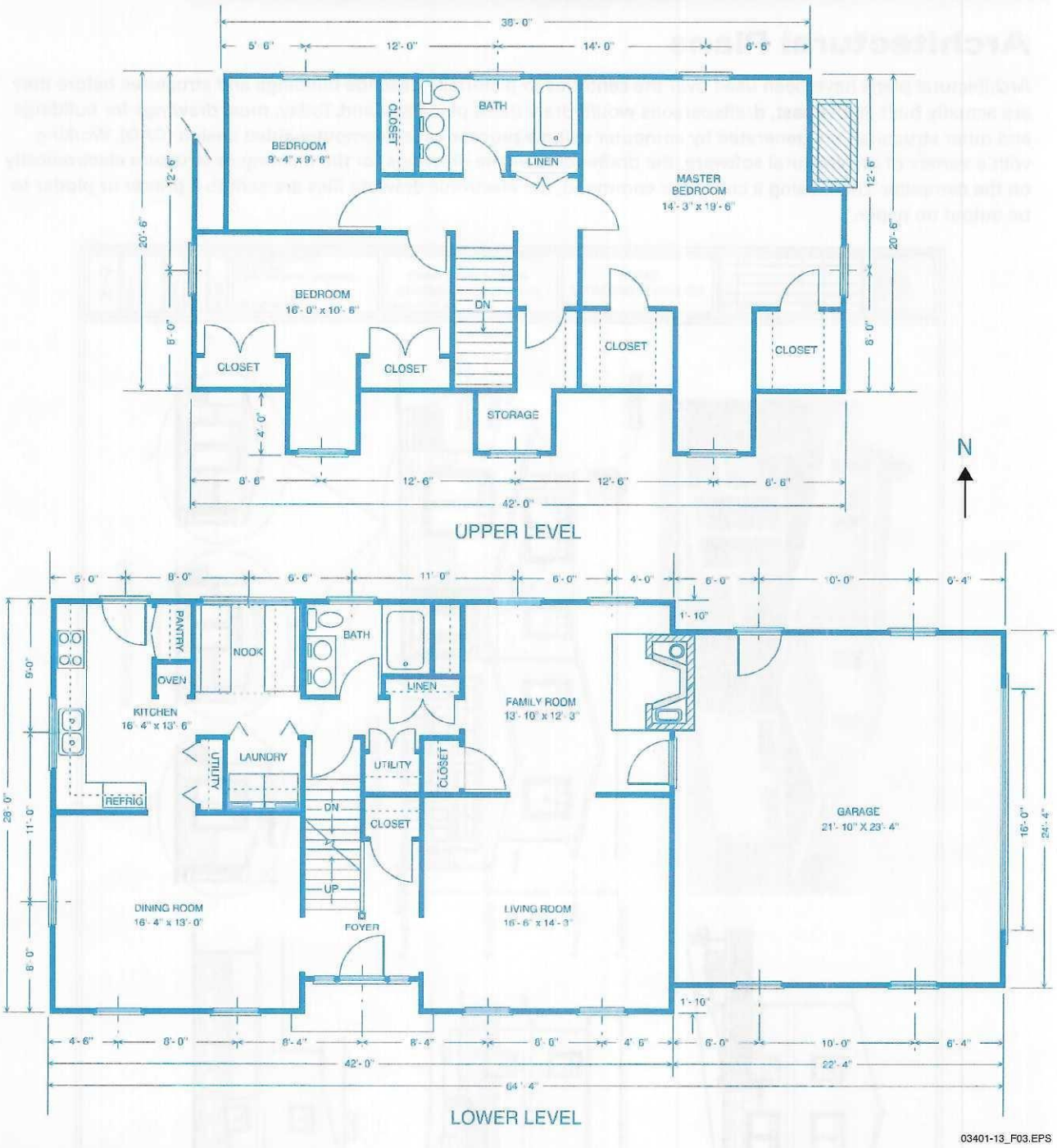


Figure 3 Floor plans for a building.

it were reflected down into a mirror. A reflected ceiling plan is of particular value to the HVAC contractor, providing information that identifies the location of supply diffusers, exhaust grilles, access panels, and other structural components.

1.3.2 Elevation Drawings

The **elevation view** of a structure (*Figure 6*) shows the exterior features of that structure. Unless one or more views are identical, four views are generally used to show each exposure. With very complex buildings, more than four views may be required. Elevation drawings show the exterior style of the building as well as the placement of doors, windows, chimneys, and decorative trim.

The various views are usually labeled in one of two ways. They may be broken down as front view, right side view, left side view, and rear view, or they may be designated by compass direction.

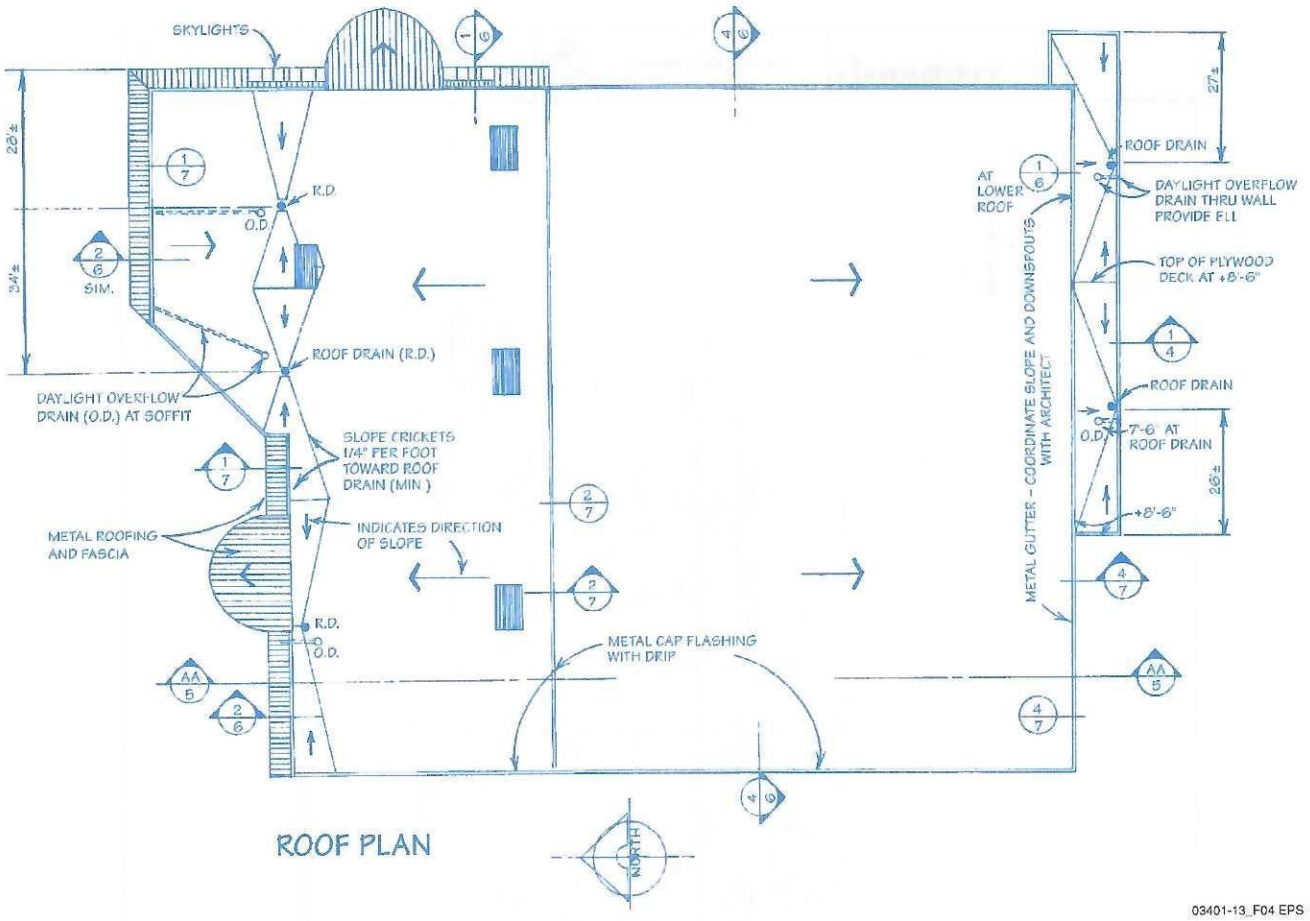


Figure 4 Roof plan.

If the front of the building faces east, then this becomes the east elevation. The other elevations are then labeled accordingly: west, south, and north.

Materials used for the exterior finish of a building are also indicated on elevation drawings and described in detail in the specifications, either as part of the drawings or as a separate set of written specifications. Foundation walls, footings, and parts of a building hidden from view are shown by broken lines. Elevation drawings often show elements such as the heights of windows, doors, and porches and the pitches of roofs because all of these measurements cannot be shown conveniently on floor plans.

1.3.3 Detail Drawings

Detail drawings show enlargements of special features of a building construction, fixtures, or equipment (*Figure 7*). They are drawn to a larger scale in order to make the details clearer. Note that the scale can vary from one detail view to another on the same sheet. For residential and some commercial projects, the detail drawings are often placed on the same sheet where the feature appears in the plan. However, for large or more complex commercial projects, detailed drawings may be drawn on a different sheet than where the feature appears. When this occurs, the detail drawings are referenced to and from the sheets where they apply.

1.3.4 Section Drawings

Section drawings (*Figure 8*) are cut-away views that allow the viewer to see the inside of a structure or how something is put together internally. A feature is drawn as if a cut has been made through the middle of it. When a sectional cut is made along the long dimension of a building, it is called a **longitudinal section**. When it is made through the short dimension, it is called a **transverse section**. The point on the drawing that the section was taken from, showing where the imaginary cut has been made, is indicated by the section line. A section line is usually a dashed line with arrows on each end to indicate the direction of view. Letters and numbers identifying the section drawing are placed on the arrows or near the line.

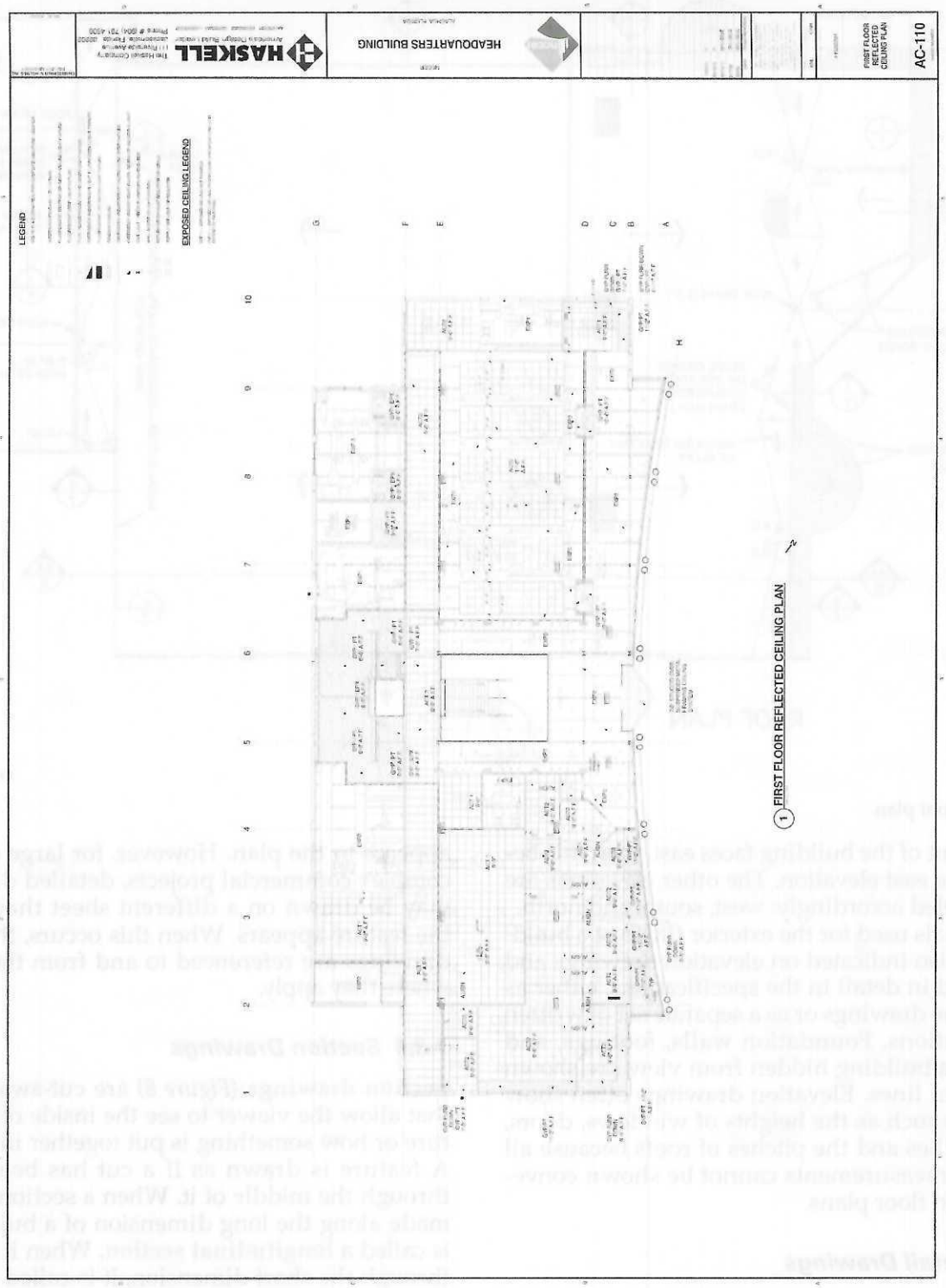


Figure 5 Reflected ceiling plan.

Like detail drawings, section drawings are drawn to a larger scale than that used in plan views. Section views are commonly given for the construction of walls, stairs, cabinets, and other building features that require more information than is given on the plan views.

Section views on mechanical plans are typically used to show more information about the in-

stallation features of a particular fixture or piece of equipment within a building. The detail views in *Figure 9* show locations for the installation of an air handler unit.

1.4.0 Plumbing, Mechanical, and Electrical Drawings

Some working drawings, such as floor plans, may also show the plumbing, mechanical, and electrical systems for a building. Often, however, these systems are shown in their own separate plans or drawings. The information that these drawings provide is particularly useful for HVAC technicians, installers, and other tradespeople.

1.4.1 Plumbing Plans

Plumbing plans show the layout of fixtures, water supply lines, natural gas piping, and lines to sewage disposal systems. The plans may be included in the floor plan of a regular construction job or on a separate plan for a large commercial structure. When drawn as a separate plan, the plumbing plan details are usually overlaid on tracings of the various building floor plans from which unnecessary details have been omitted to allow the location and layout of the plumbing systems to show clearly. *Figure 10* is a plumbing plan showing the sanitary plumbing in both plan form and as an isometric drawing.

A plumbing legend shows the various symbols pertaining to the plan (*Figure 11*). Some legends provide tabulated plumbing fixture and equipment schedules. Plumbing plans may also show a schedule of plumbing systems and plumbing system specifications. Schedules are discussed in more detail later on in this section.

1.4.2 Mechanical Plans

Mechanical plans show the heating, ventilation, and air conditioning systems, as well as other mechanical systems for a building. For some residential jobs, the mechanical plan may be combined with the plumbing plan and show very little detailed information other than the locations of the main HVAC system components. This is because the installation location of duct or piping runs is allowed to be determined on the job by the HVAC contractor. For large commercial jobs, the mechanical plans typically show detailed information about the HVAC system installation and the installation of other equipment. Information

Floor Plans

The floor plan is a drawing of the structure as if it were cut horizontally about 4' above floor level and viewed from above. This horizontal cutting plane will show most of the windows and doors.

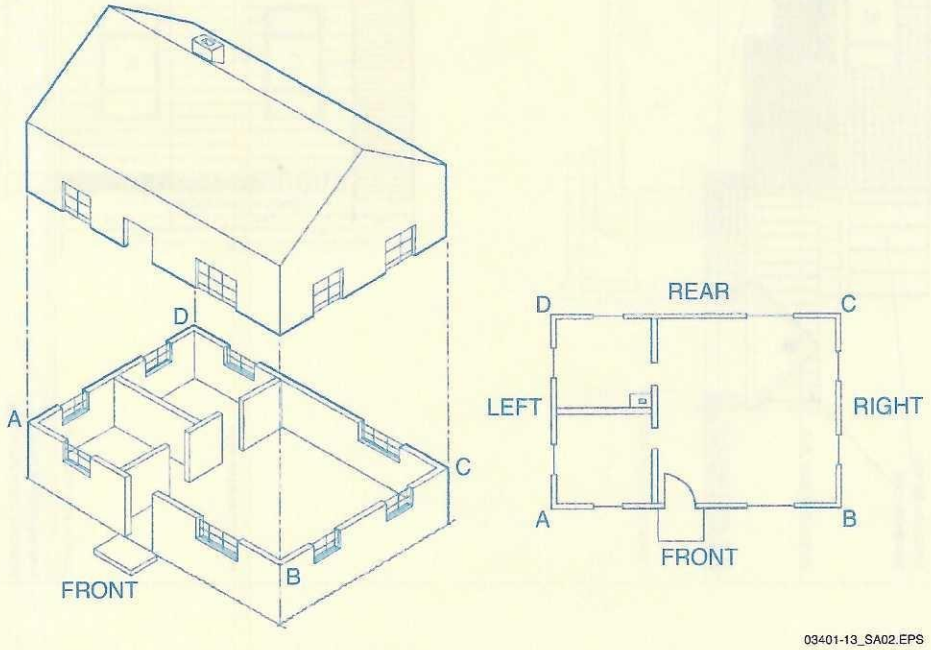


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Figure 6 Elevation drawing.

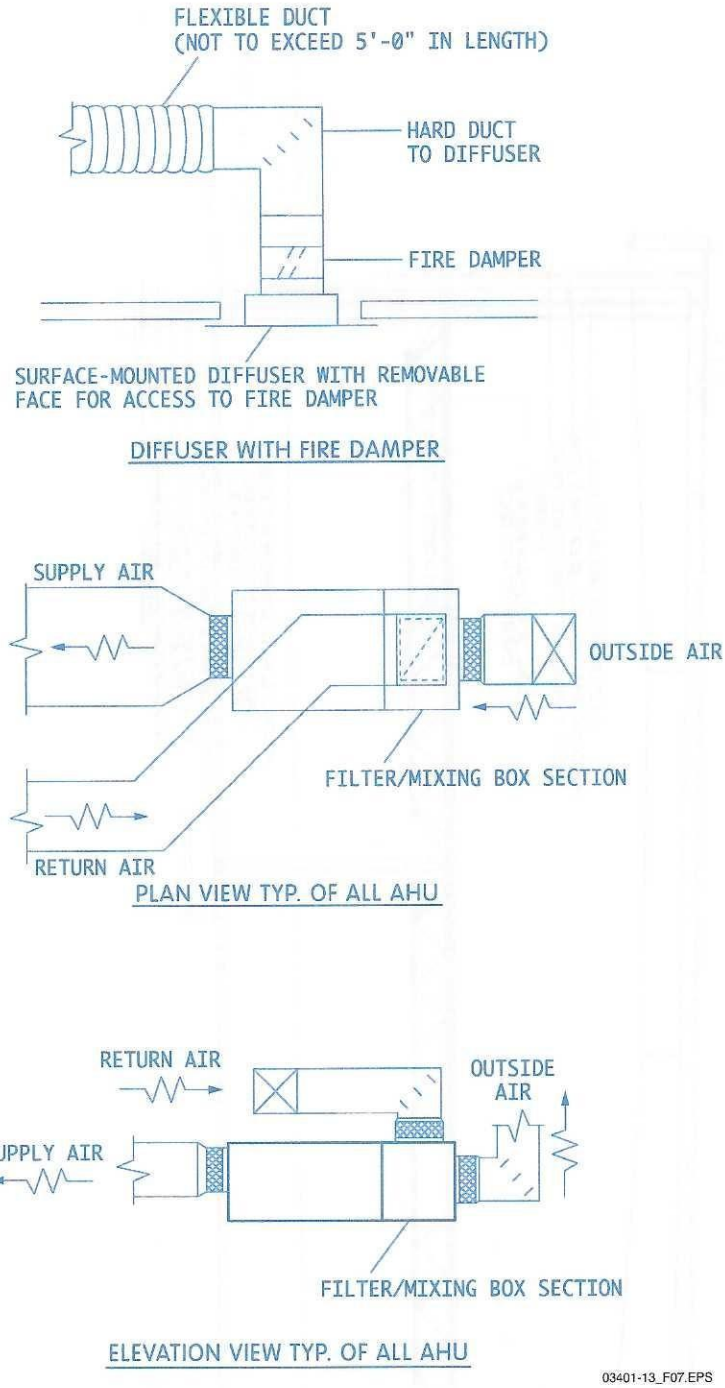

Figure 7 Equipment-related detail drawings.

Check the Legend

To avoid making mistakes when reading the drawings, be sure you understand the symbols and abbreviations used in the plumbing, HVAC, and electrical legends on every drawing set. Symbols and abbreviations may vary widely from one drawing set to another.

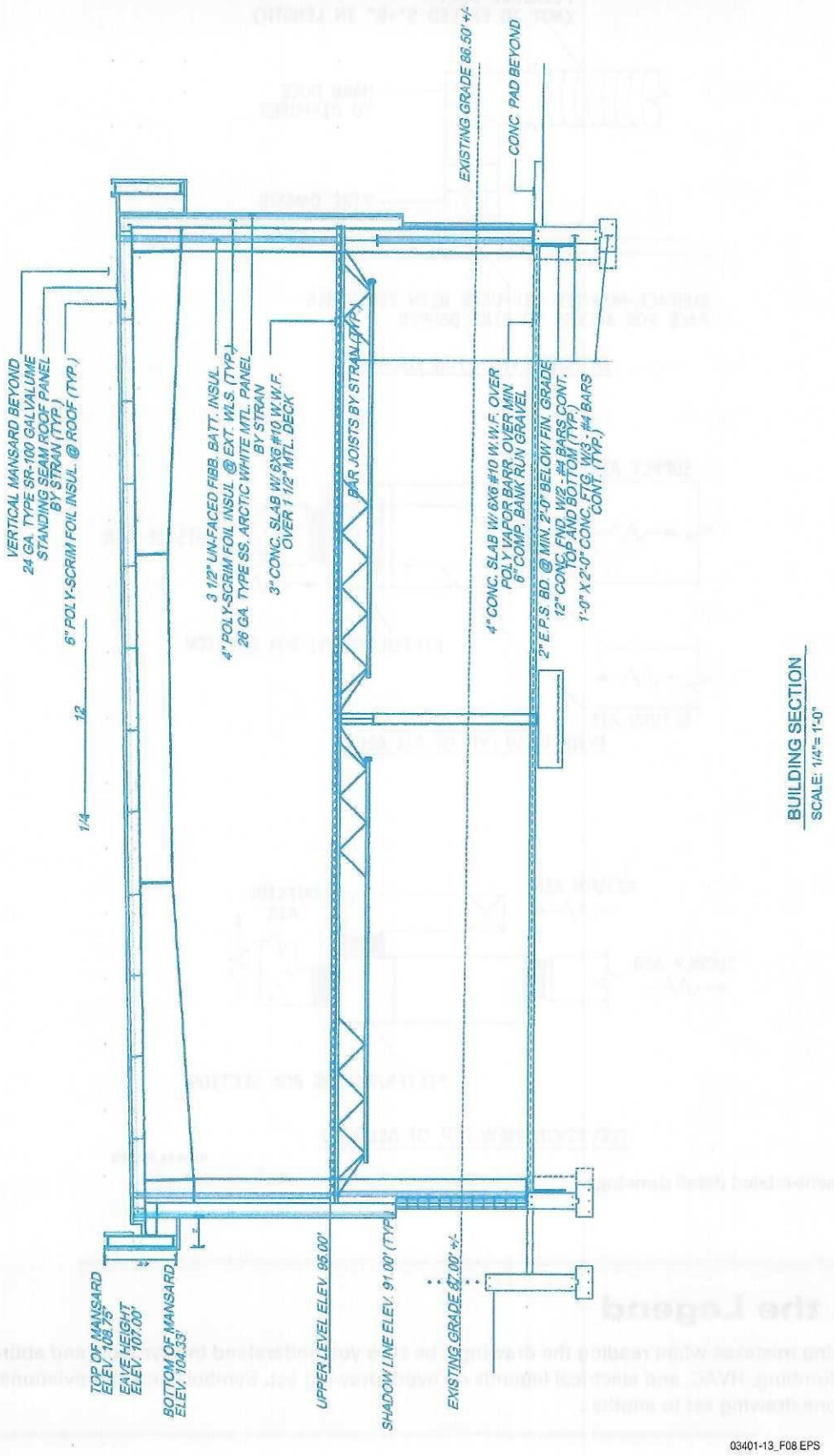

Figure 8 Section drawing showing building construction.

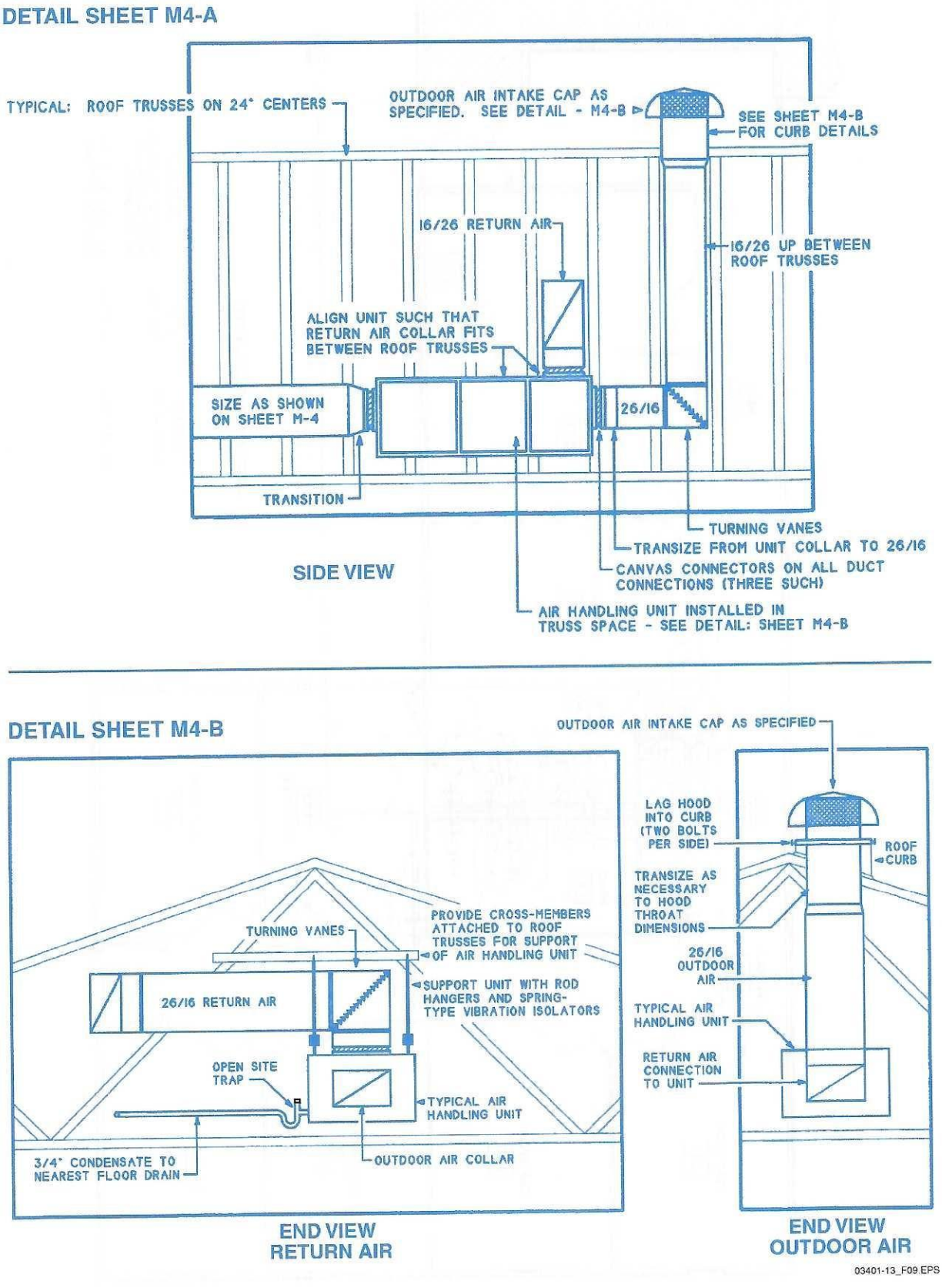

Figure 9 Section drawings showing air handling unit installation.

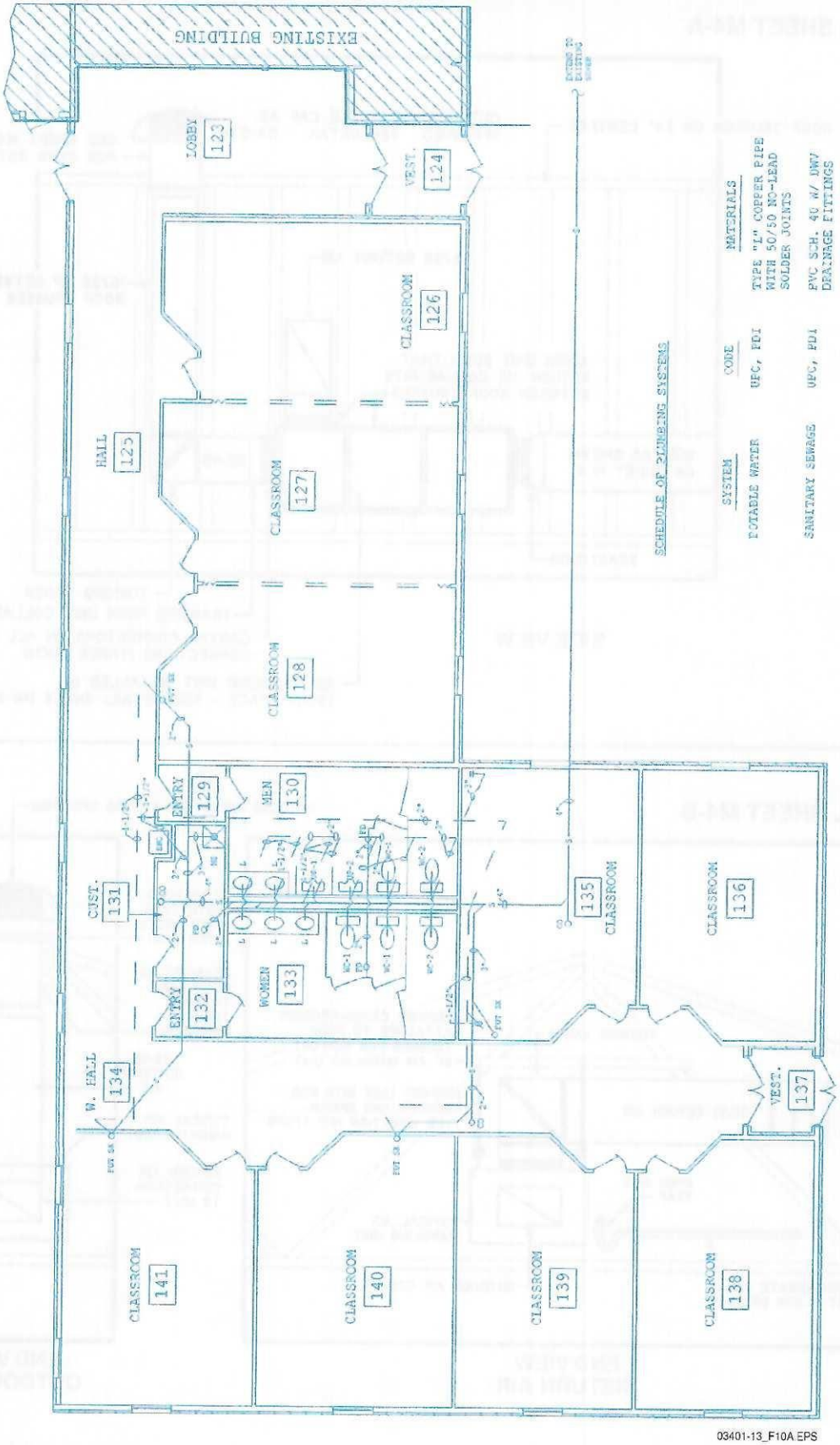

Figure 10 Sanitary plumbing plan (1 of 2).

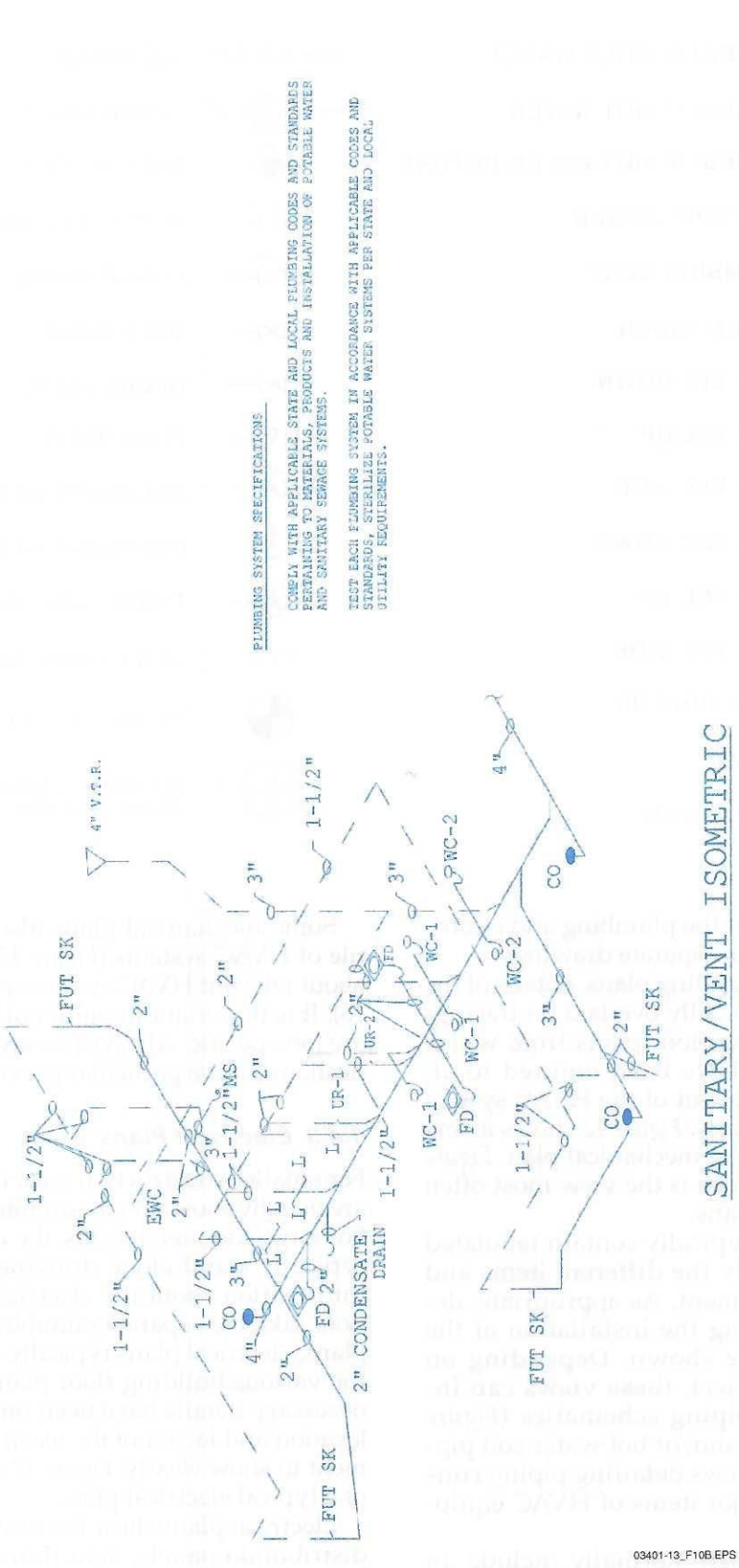

Figure 10 Sanitary plumbing plan (2 of 2).

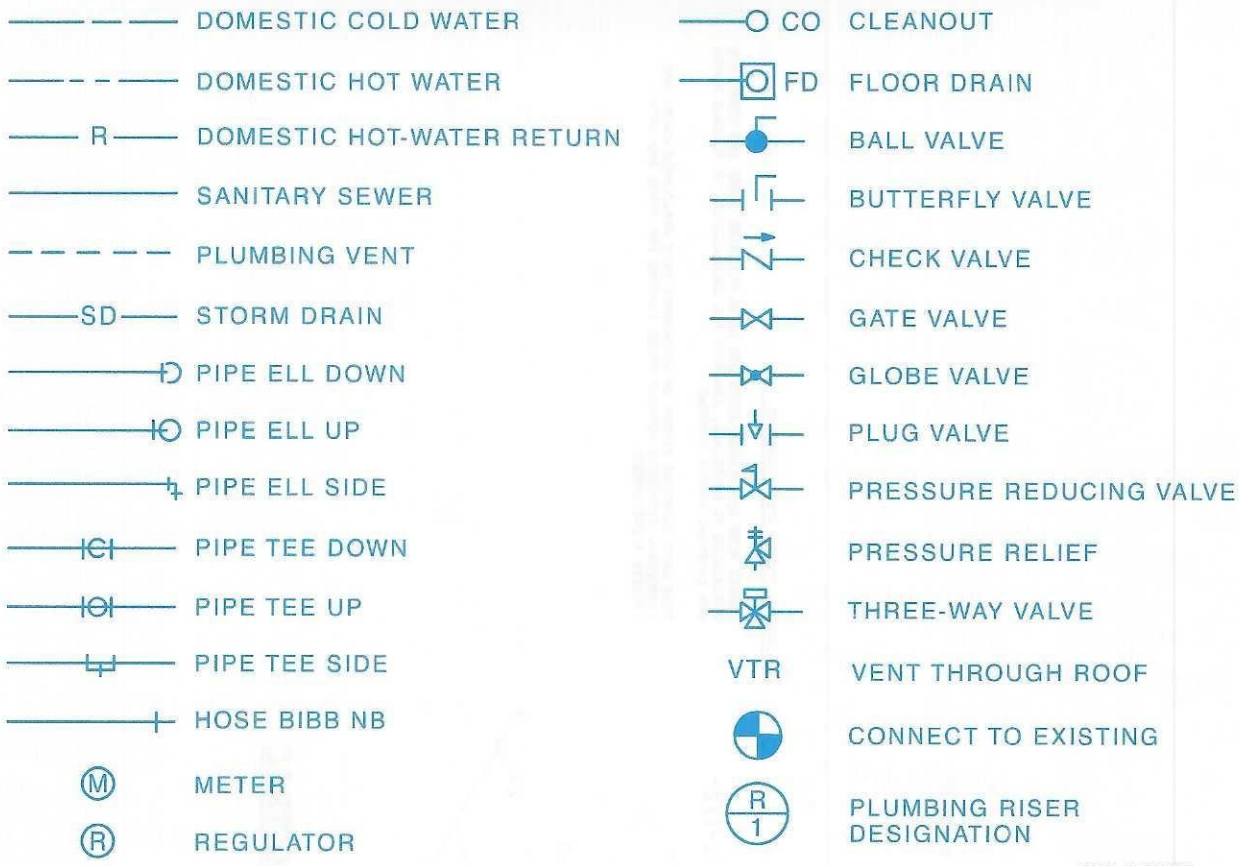

Figure 11 Plumbing legend.

about the installation of the plumbing and electrical systems is shown on separate drawings.

As with separate plumbing plans, details of the mechanical plan are usually overlaid on tracings of the various building floor plans from which unnecessary details have been omitted to allow the location and layout of the HVAC system equipment to show clearly. *Figure 12* shows an example of a typical HVAC mechanical plan. *Figure 12A* is a plan view, which is the view most often used for mechanical plans.

Mechanical plans typically contain tabulated schedules that identify the different items and types of HVAC equipment. As appropriate, detailed views describing the installation of the HVAC equipment are shown. Depending on the nature of the project, these views can include refrigeration piping schematics (*Figure 13*), chilled-water coil and/or hot-water coil piping schematics, and views detailing piping runs and pipe sizes for major items of HVAC equipment.

Mechanical plans also normally include an HVAC legend listing the various symbols pertaining to the plan. *Figure 14* shows a partial HVAC legend.

Some mechanical plans also contain a schedule of HVAC systems (*Figure 15*) and information about relevant HVAC system specifications (*Figure 16*). It is important to point out that specifications are job-specific. Always be sure to read the specifications for the particular job you are working on.

1.4.3 Electrical Plans

For smaller construction jobs, the electrical plans are usually shown on the architectural floor plans. For large commercial jobs, the electrical plans are typically stand-alone drawings that show only information about the electrical system installation. Like the separate plumbing and mechanical plans, electrical plans typically overlay tracings of the various building floor plans from which unnecessary details have been omitted to allow the location and layout of the electrical system equipment to show clearly. *Figure 17* shows an example of a typical electrical plan.

Electrical plans show the locations of the meter, distribution panels, light fixtures, switches, and other electrical equipment. Also shown are equipment and fixtures schedules, an electrical legend listing the various symbols pertaining to the plan, specifications for load capacities, and wire sizes.

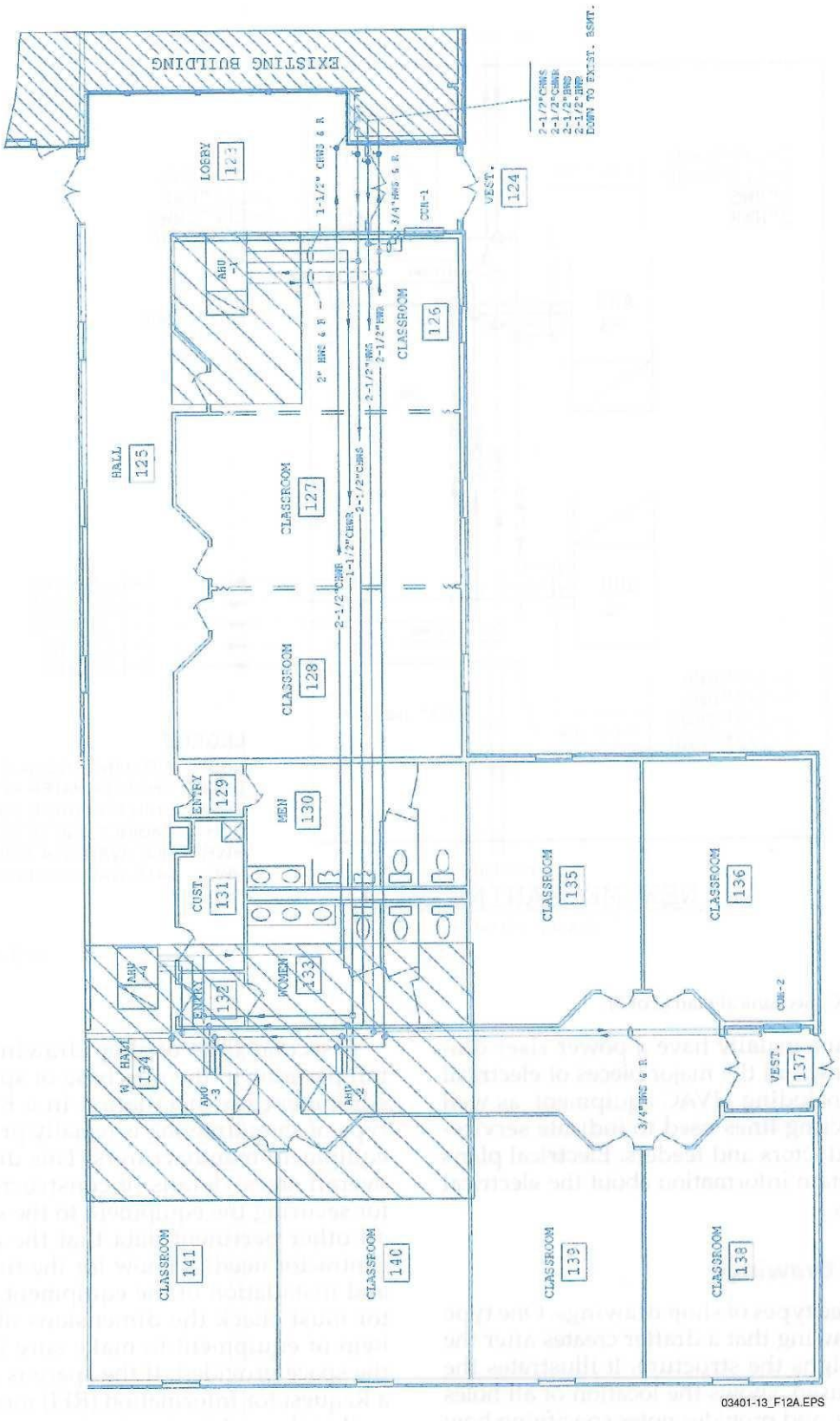

Figure 12 HVAC mechanical plan (1 of 3).

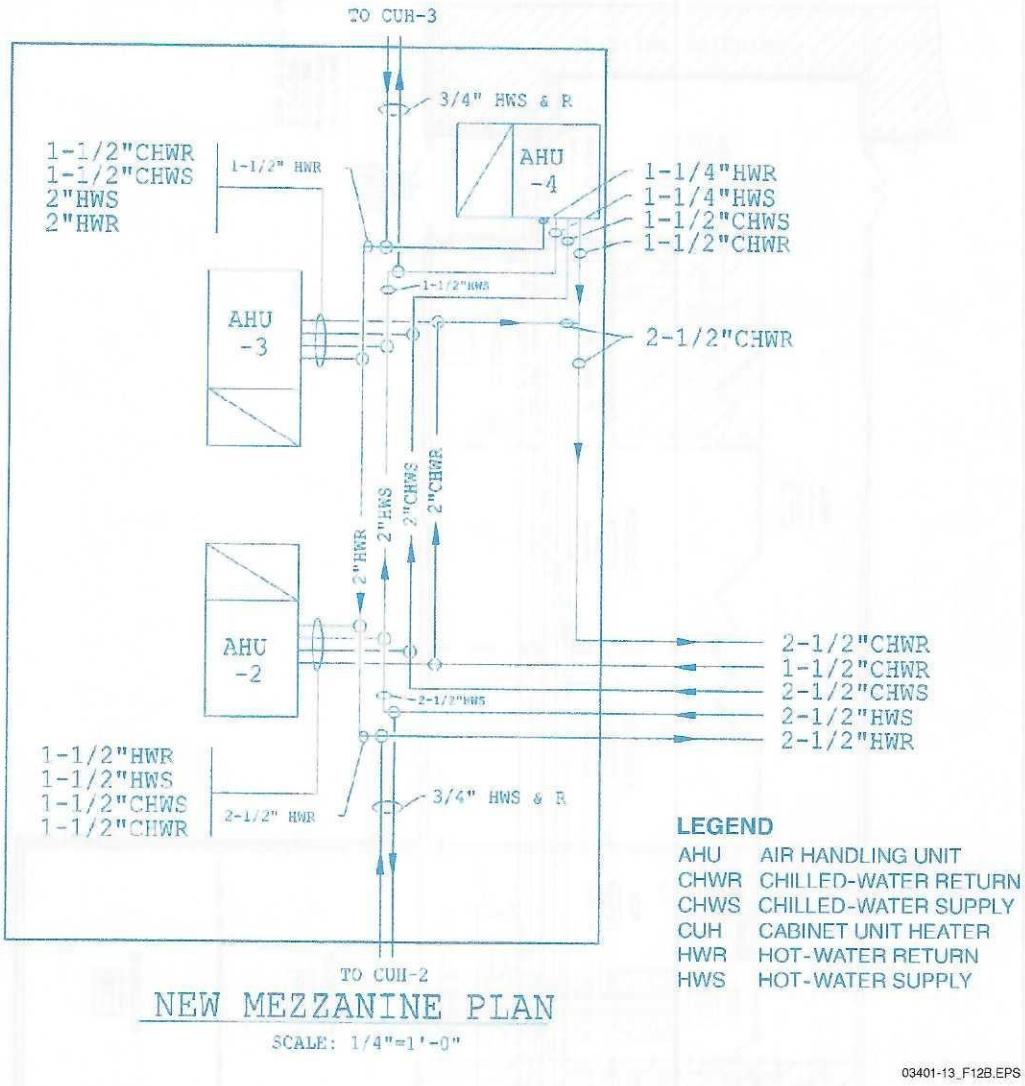

Figure 12 HVAC mechanical plan (2 of 3).

Electrical plans usually have a power **riser diagram** that shows all the major pieces of electrical equipment, including HVAC equipment, as well as the connecting lines used to indicate service-entrance conductors and feeders. Electrical plans may also contain information about the electrical specifications.

1.5.0 Shop Drawings

There are three types of **shop drawings**. One type is a detail drawing that a drafter creates after the engineer designs the structure. It illustrates the connections used, shows the location of all holes and openings, and provides notes specifying how each part is to be made. Assembly instructions are also included and are used principally for structural steel members.

A second type of shop drawing (or submittal) pertains to the purchase of special items of equipment for installation in a building. This type of shop drawing is usually prepared by the equipment manufacturers. This drawing shows overall sizes, details of construction, methods for securing the equipment to the structure, and all other pertinent data that the architect and contractor need to know for the final placement and installation of the equipment. The contractor must check the dimensions of a submitted item of equipment to make sure it will fit into the space provided. If the space is not adequate, a Request for Information (RFI) form is filled out so that the architect or engineer responsible can correct the problem.

A third type of shop drawing very similar in development to the structural steel shop draw-

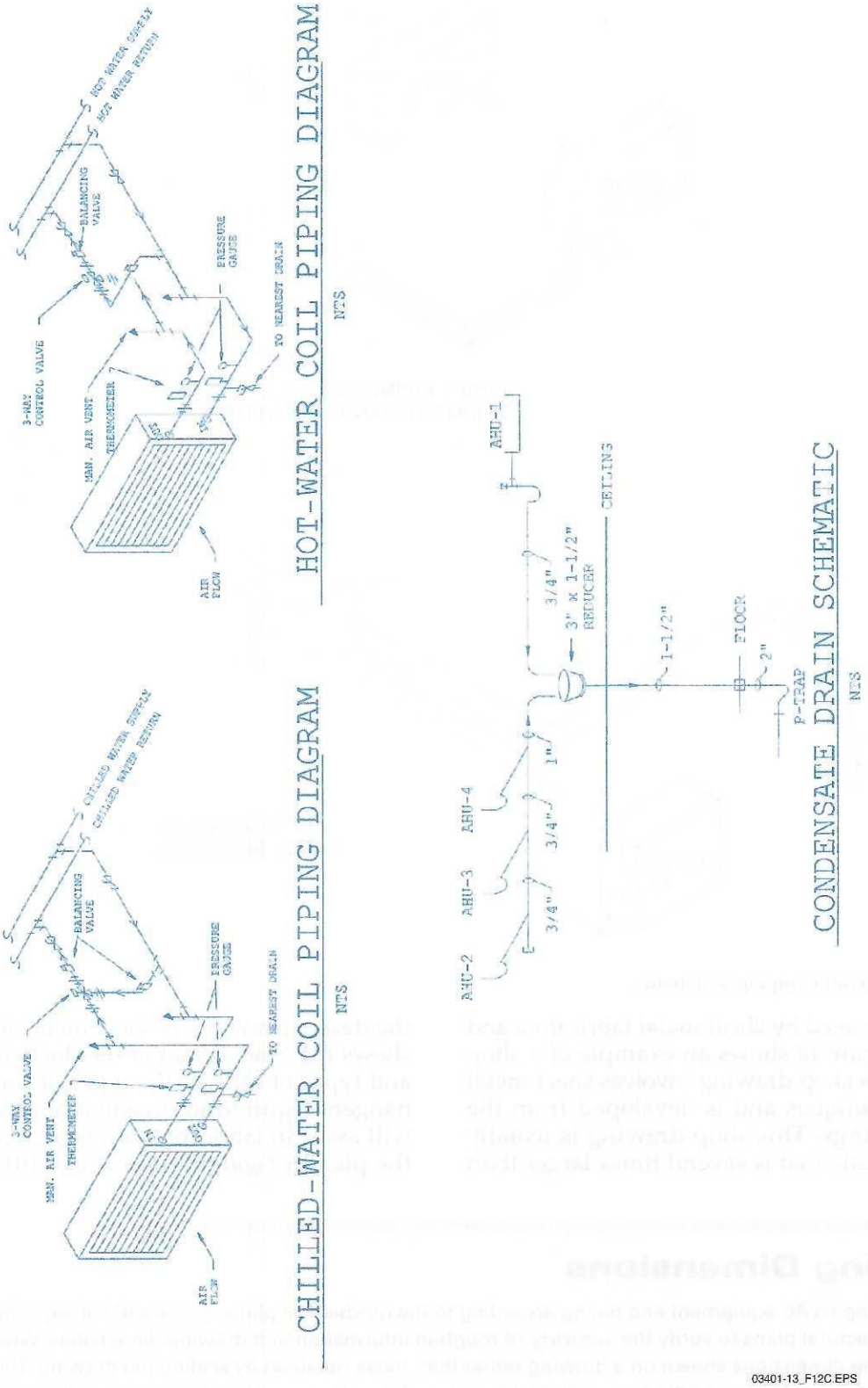

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Figure 12 HVAC mechanical plan (3 of 3).

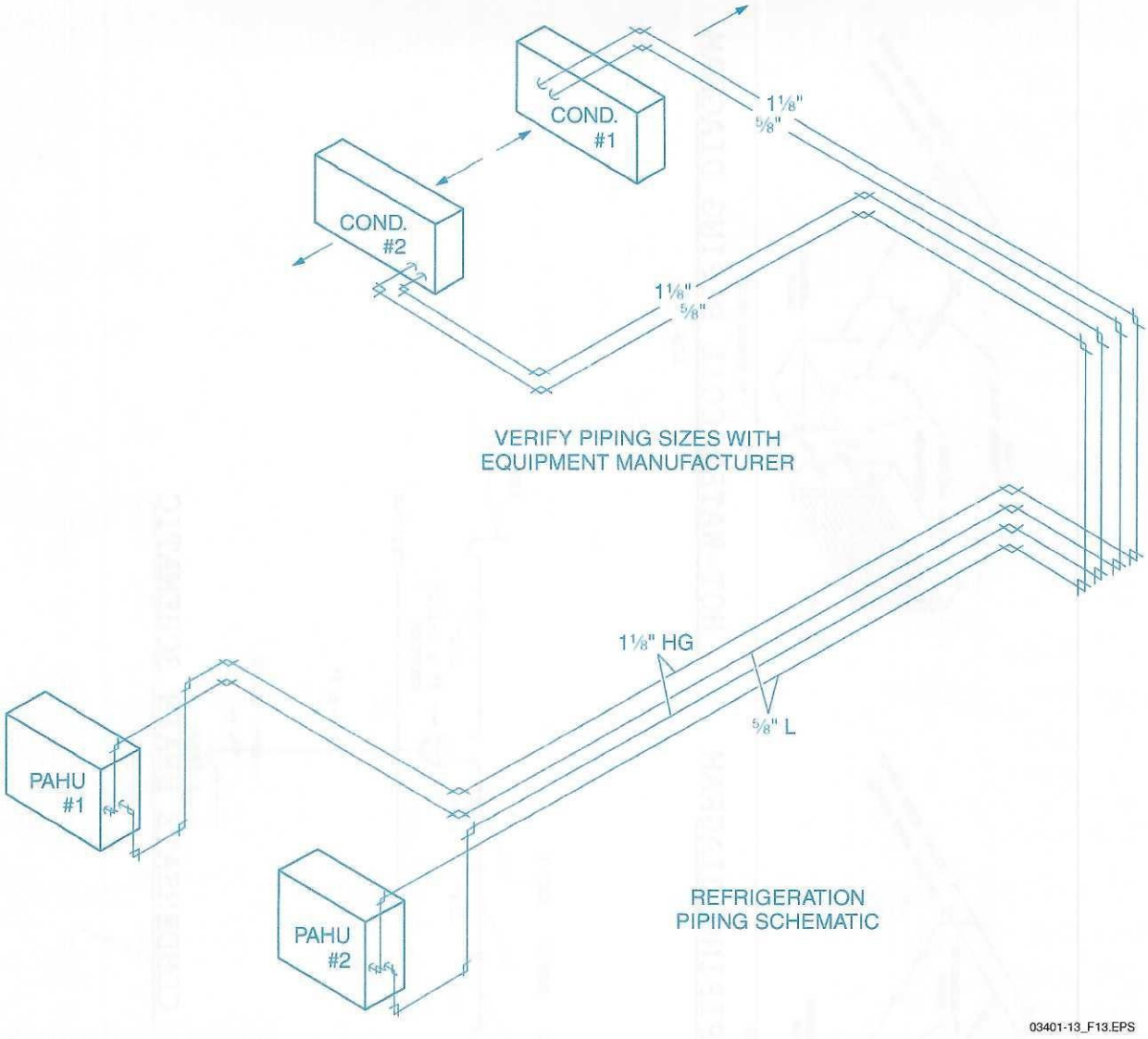

Figure 13 Refrigeration piping schematic.

ing is the one used by sheet metal fabricators and installers. *Figure 18* shows an example of a shop drawing. This shop drawing involves sheet metal drafting techniques and is developed from the design drawings. This shop drawing is usually drawn to a scale that is several times larger than the design drawing. A sheet metal shop drawing shows the exact layout of the ductwork, the sizes and types of fittings, the types of connectors and hangers required for installation, and notes that will assist in fabrication or installation. Although the plan in *Figure 18* may seem difficult to read

Verifying Dimensions

When installing HVAC equipment and piping according to the mechanical plans, you should always check the related architectural plans to verify the accuracy of rough-in information and drawing dimensions. When given, always use the dimensions shown on a drawing rather than those obtained by scaling the drawing. This is because some reproduction methods used to make copies of drawings can introduce errors in the reproduced image.

Also, when devices are to be located at heights specified above the finished floor (AFF), be sure to find out the actual height of the flooring to be installed. Some materials such as ceramic tile can add significantly to the height of the finished floor.

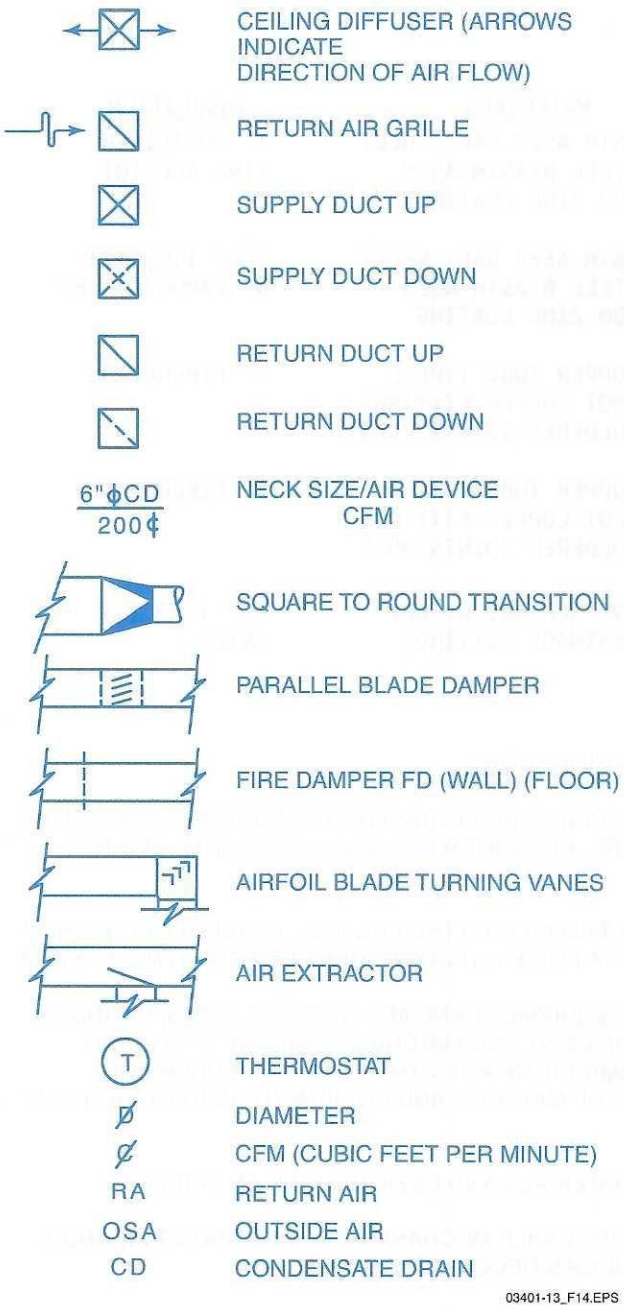

Figure 14 HVAC legend.

here, the details are much more visible on a full-size drawing sheet.

The first and second types of shop drawings usually come from the contractor or fabricator and are submitted to the owner or architect for approval and/or revisions or corrections. The design drawing is often put on the same sheet as the shop drawing. Shop drawings are drawn to a large enough scale so that they are clear, but they must not be crowded. They are usually dimensioned to the nearest 1/16 of an inch.

Contractors commonly use the following approach for the development of shop drawings. When the contract is signed, a full set of drawings is given to the mechanical contractor's drafting department. Upon receipt of the mechanical drawings, the drafting department, depending on the workload, immediately begins developing the shop drawings. As the shop drawings are taken from the mechanical prints, the drafting department also researches the plumbing, electrical, HVAC piping, architectural, and structural prints to see if there will be any conflicts. These drawings are commonly called **coordination drawings**.

Coordination drawings are drawings produced for a project by the individual contractors for each trade to prevent a conflict between the trades in the installation of their materials and equipment. They are produced prior to finalizing shop drawings, **cut lists** (shop guides for fabricating duct runs and fittings), and other drawings and before the installation process begins. Development of these drawings evolves through a series of review and coordination meetings held by the various contractors.

Some contracts mandate that coordination drawings be drawn, while others only recommend it. In the case where one contractor elects to make coordination drawings and another does not, the contractor who made the drawings may be given the installation right-of-way by the presiding authority. As a result, the other contractor may have to bear the expense of removing and

Drawing Revisions

When a set of construction drawings has been revised, always make certain that the most up-to-date set is used for all future layout work. Either destroy the old, obsolete set of drawings or else clearly mark on the affected sheets Obsolete Drawing—Do Not Use. A good practice is to remove the obsolete drawings from the set and file them as history copies for possible future reference. Also, when working with a set of construction drawings and written specifications for the first time, thoroughly check each page to see whether any revisions or modifications have been made to the originals. Doing so can save time and expense for everyone concerned with the project.

SCHEDULE OF HVAC SYSTEMS

SYSTEM	CODE	MATERIALS	INSULATION
METAL DUCTWORK	SMACNA NFPA 90 A & B	ASTM A527 GAL. SHEET STEEL W/ASTM A525 G90 ZINC COATING	1" DUCTLINER TIMA AHC-101
ROUND DUCTWORK	SMACNA NFPA 90 A & B	ASTM A527 GAL. SHEET STEEL W/ASTM A525 G90 ZINC COATING	1½" DUCTWRAP W/ VAPOR JACKET
HOT WATER	ASME 31.9	COPPER TUBE TYPE L WROT COPPER FITTINGS SOLDERED JOINTS 95/5	1" FIBERGLASS
CHILLED WATER	ASME 31.9	COPPER TUBE TYPE L WROT COPPER FITTINGS SOLDERED JOINTS 95/5	1" FIBERGLASS
CONDENSATE	UPC, PDI	PVC SCH 40, W/ DWV DRAINAGE FITTINGS	½" FLEXIBLE UNICELL

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Figure 15 Schedule of HVAC systems.

HEATING, VENTILATING & AIR CONDITIONING SYSTEM SPECIFICATIONS

COMPLY WITH APPLICABLE MECHANICAL CODES AND STANDARDS PERTAINING TO MATERIALS, PRODUCTS, AND INSTALLATION OF AIR HANDLING, METAL DUCTWORK, HOT-WATER SYSTEMS, AND CHILLED-WATER SYSTEMS.

SUBMIT MANUFACTURER'S TECHNICAL PRODUCT DATA TAILORED TO THE PROJECT, ASSEMBLY-TYPE SHOP DRAWINGS, WIRING DRAWINGS, AND MAINTENANCE DATA FOR EACH COMPONENT OF EACH HVAC SYSTEM.

PROVIDE FACTORY-FABRICATED AND FACTORY-TESTED EQUIPMENT AND MATERIALS OF SIZES, RATINGS, AND CHARACTERISTICS INDICATED. REFERENCED EQUIPMENT AND MATERIALS INDICATE STYLE AND QUALITY DESIRED. CONTACT ENGINEER PRIOR TO SUBMITTAL OF ANY OTHER MANUFACTURER FOR PRELIMINARY APPROVAL. PROVIDE PROPER QUANTITY OF MATERIAL AND EQUIPMENT AS REQUIRED FOR COMPLETE INSTALLATION OF EACH HVAC SYSTEM.

IDENTIFY EACH HVAC SYSTEM'S COMPONENTS WITH MATERIALS AND DESIGNATIONS AS DIRECTED.

INSTALL EACH HVAC SYSTEM IN ACCORDANCE WITH APPLICABLE MECHANICAL CODES AND STANDARDS, RECOGNIZED INDUSTRY PRACTICES, AND MANUFACTURER'S RECOMMENDATIONS.

TEST AND BALANCE EACH HVAC SYSTEM IN ACCORDANCE WITH APPLICABLE MECHANICAL CODES AND STANDARDS. BALANCE AIR CONDITIONING SYSTEM TO CFM'S SHOWN ON DRAWINGS. REPORT FINDINGS TO ENGINEER USING APPROVED FORMS.

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Figure 16 Example of HVAC system specifications information.

reinstalling equipment if the equipment was installed in a space designated for use by the contractor who produced coordination drawings.

1.5.1 Cut Lists

Another function of the shop drawing is to assist the subcontractor in identifying the number and sizes of the fittings and duct run sections that must be fabricated and subsequently installed on the job.

After the shop drawings are complete, or as they are drawn (depending on the workload), the drafter makes a cut sheet of each individual fitting and assigns a fitting number to it that matches the numbers on the shop drawing.

The straight duct sections are given another number that stays the same until the duct size

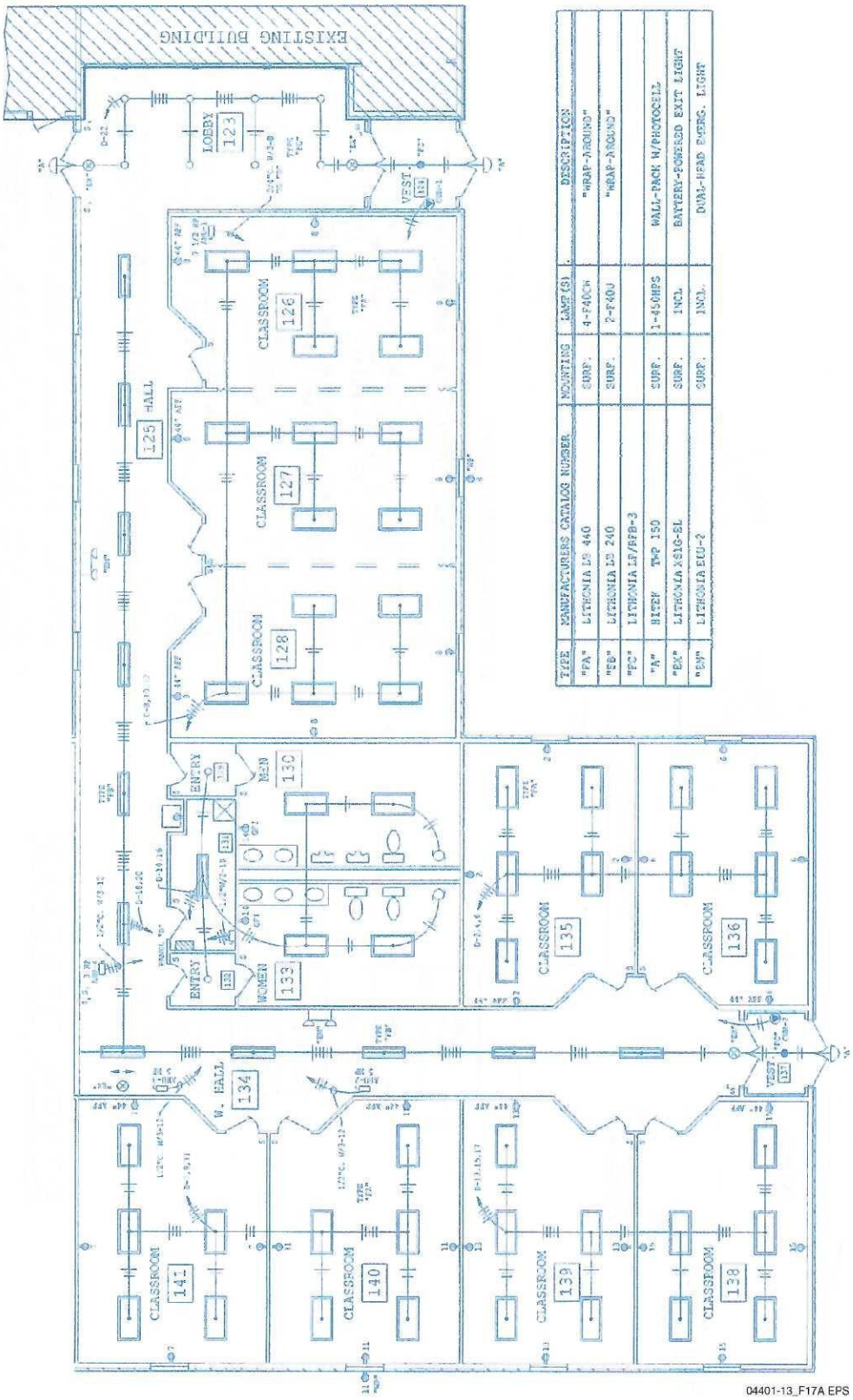
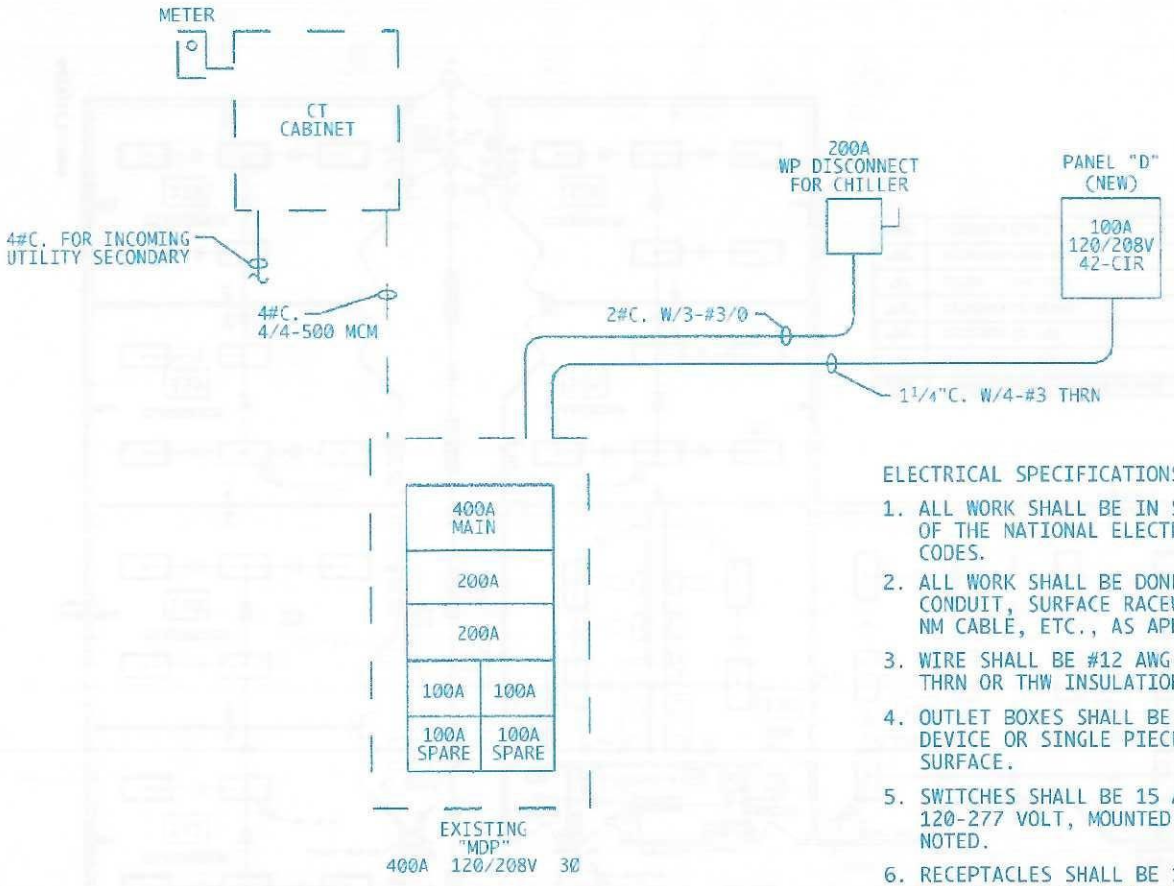


Figure 17 Electrical plan (1 of 2).



RISER DIAGRAM

NTS

ELECTRICAL SPECIFICATIONS

1. ALL WORK SHALL BE IN STRICT COMPLIANCE WITH LATEST EDITION OF THE NATIONAL ELECTRIC CODE AND APPLICABLE STATE AND LOCAL CODES.
2. ALL WORK SHALL BE DONE USING IMC, EMT, PVC, ENT, FLEXIBLE CONDUIT, SURFACE RACEWAY, CABLE TRAY, MC CABLE, AC CABLE, NM CABLE, ETC., AS APPROPRIATE FOR THE SPECIFIC APPLICATION.
3. WIRE SHALL BE #12 AWG MINIMUM UNLESS OTHERWISE NOTED, WITH THRN OR THW INSULATION AND COPPER CONDUCTORS.
4. OUTLET BOXES SHALL BE 4" SQUARE FITTED WITH APPROPRIATE DEVICE OR SINGLE PIECE MASONRY-TYPE SET FLUSH WITH FINISHED SURFACE.
5. SWITCHES SHALL BE 15 AMP SPECIFICATION GRADE EQUAL TO P & S 501, 120-277 VOLT, MOUNTED AT 44" ABOVE FLOOR UNLESS OTHERWISE NOTED.
6. RECEPTACLES SHALL BE 15 AMP SELF-GROUNDING SPECIFICATION GRADE EQUAL TO 5242, MOUNTED AT 18" ABOVE FLOOR UNLESS OTHERWISE NOTED.
7. RECEPTACLES, SWITCH, TELEPHONE, ETC., COVER PLATES SHALL BE SMOOTH IVORY PLASTIC EQUAL TO SIERRA "P" SERIES.
8. MATERIAL AND EQUIPMENT SHALL BE NEW, OF STANDARD MANUFACTURER'S CONSTRUCTION, INSTALLED IN ACCORDANCE WITH ACCEPTED PRACTICE BY COMPETENT WORKERS.

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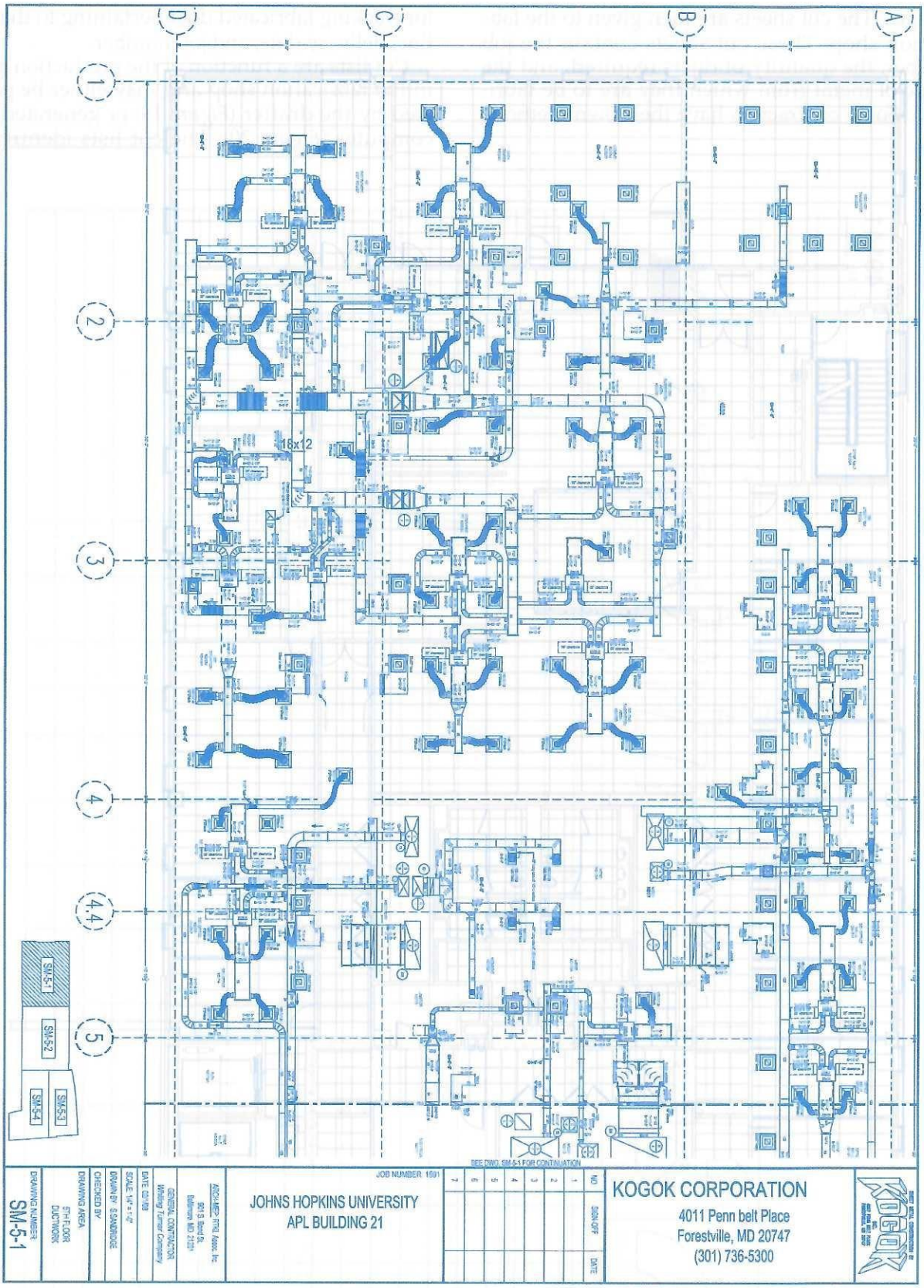
Figure 17 Electrical plan (2 of 2).

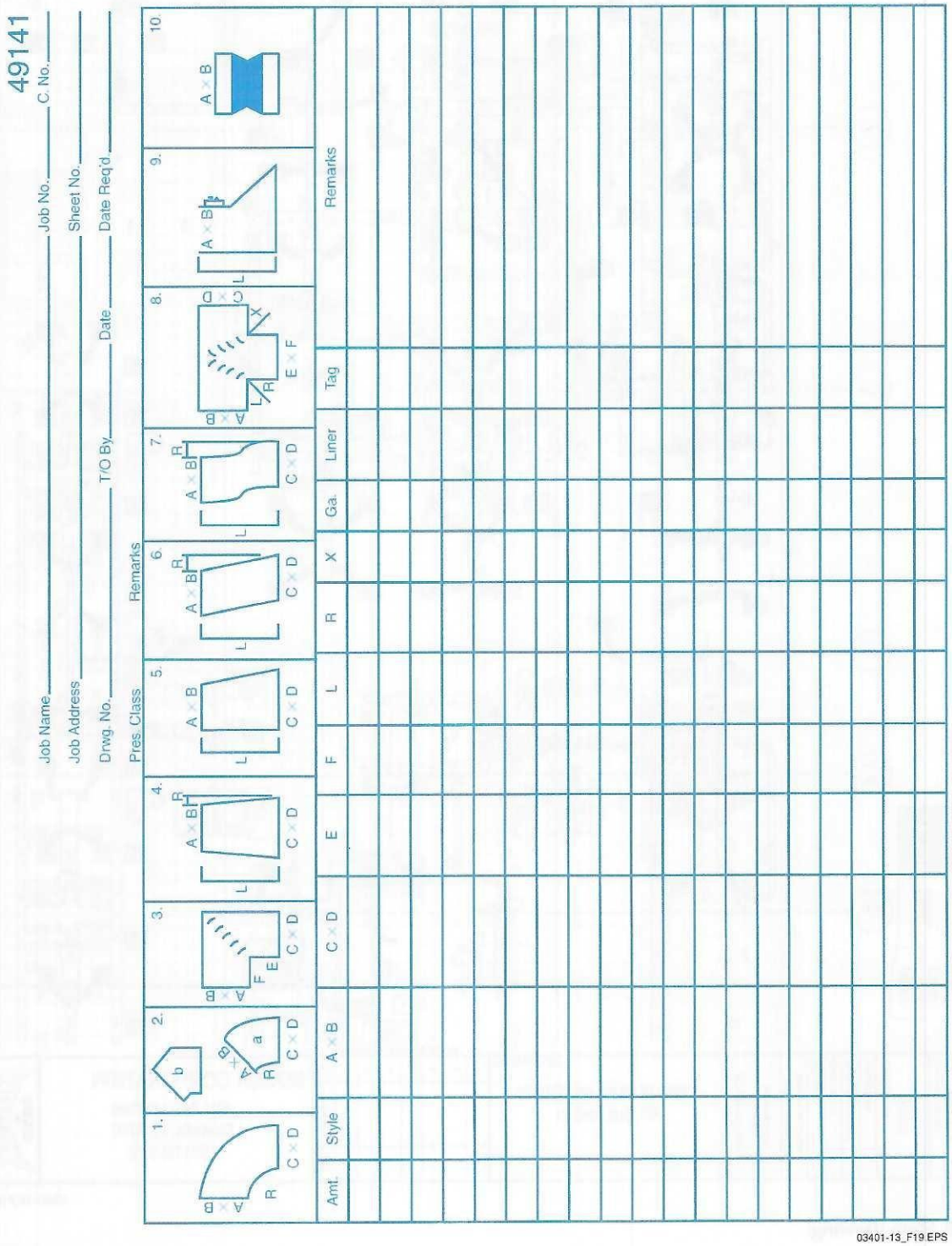


03401-13_F18.EPS

Figure 18 Shop drawing.

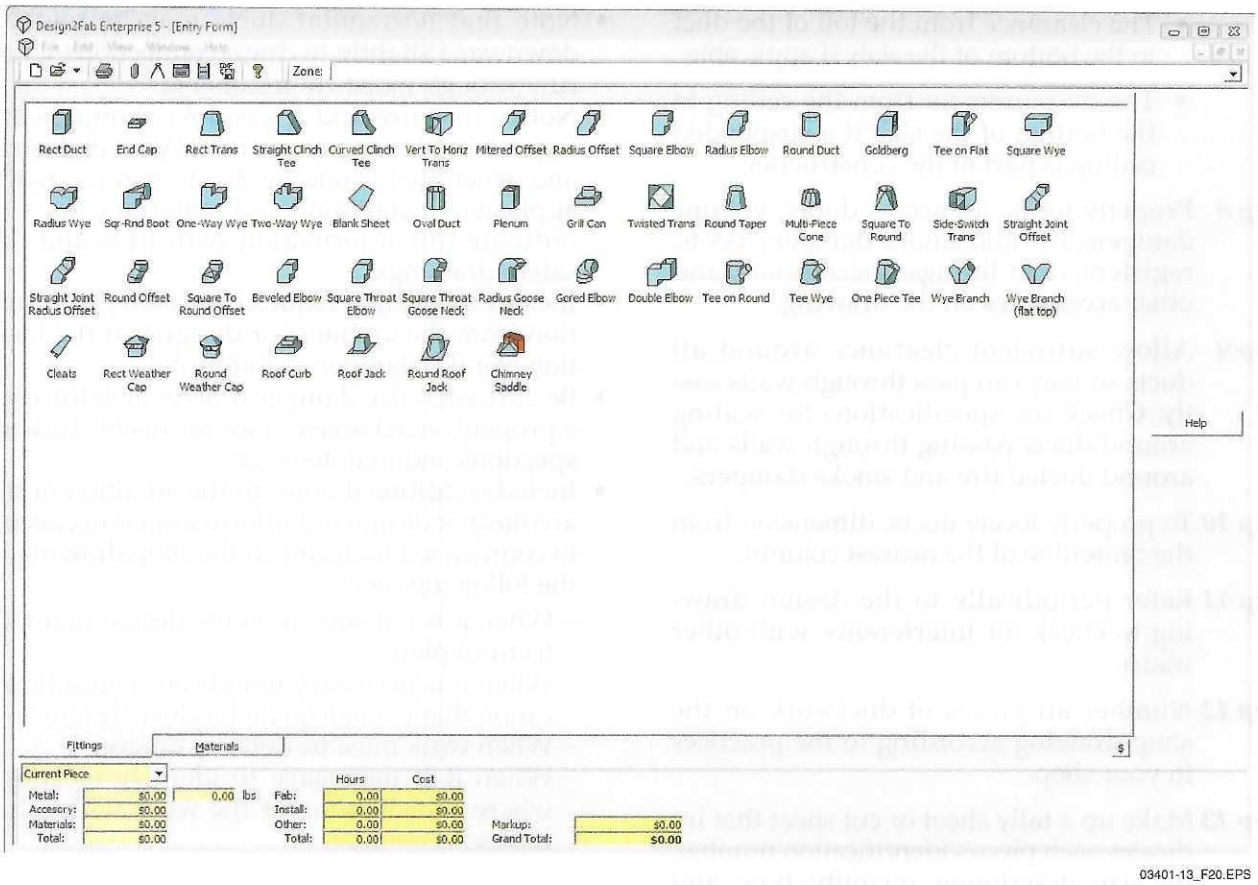
changes. The cut sheets are then given to the fabrication shop. These cut sheets contain the job number, the quantity of ducts required, and the gauge of metal from which they are to be fabricated. Some contractors have their own methods for tracking fabricated duct pertaining to the duct line, delivery date, and job number.

Cut lists are a function of the production phase in the fabrication shop and may either be generated by the drafter (*Figure 19*) or generated by a computer (*Figure 20*). The cut lists identify the



03401-13_F19.EPS

Figure 19 Drafter's cut list.



03401-13_F20.EPS

Figure 20 Computer-generated cut list.

fittings and sections by number, type of fitting, amount required, width, depth, length, type of flange or connection to be used, number of parts required for the fitting, cut size, and type and gauge of metal.

1.5.2 General Procedures

In large shops, the sheet metal drafters are usually sheet metal mechanics who have been trained in the use of drawing instruments and layout procedures. In smaller shops, the owner or journeyperson may be required to develop the shop drawings. Freehand sketches from field measurements are often passed on to the drafter to develop a shop drawing. Sometimes, written notes and descriptions are provided, and the drafter must translate that information into shop drawings. A general procedure for producing shop drawings is as follows:

Step 1 Select a scale two to four times larger than the scale used for the design drawing. The scale selected should suit the intended purpose of the drawing. If the drawing is to be used as a coordination drawing, then each contractor should use the same scale in order to make comparisons among the drawings easier. Sometimes the engineers or architects will provide a basic template for the drawing that helps achieve accuracy in the layout.

Step 2 Arrange the layout to be evenly spaced on the sheet; it may be desirable to center the layout.

Step 3 Use the standard symbols on the drawing.

Step 4 Add notes when and where necessary.

Step 5 Draw in partitions, exterior walls, beams, columns, hanging ceilings, and any other obstructions that appear on the architectural plan.

Step 6 Use the design drawing to calculate all measurements needed to properly locate the ductwork.

Step 7 When dimensioning, indicate:

- The measurements from the finished floor to the bottom of the duct
- The duct height

- The clearance from the top of the duct to the bottom of the slab, if applicable
- The measurement from the ceiling to the bottom of the slab if a suspended ceiling is part of the construction

Step 8 Properly locate all access doors, volume dampers, fire and smoke dampers, boots, registers, duct linings, thermostats, and other accessories on the drawing.

Step 9 Allow sufficient clearance around all ducts so they can pass through walls easily. Check the specifications for sealing around ducts passing through walls and around ducted fire and smoke dampers.

Step 10 To properly locate ducts, dimension from the centerline of the nearest column.

Step 11 Refer periodically to the design drawing to check for interference with other trades.

Step 12 Number all pieces of ductwork on the shop drawing according to the practices in your shop.

Step 13 Make up a tally sheet or cut sheet that indicates each piece's identification number, the size, description, quantity, type, and gauge of material, and any other pertinent information that will help the fabricator and/or installer.

In addition, consider the following factors when you prepare shop drawings:

- Carefully check the electrical and plumbing mechanical drawings when preparing drawings for ducts.
- Note that the types of connections used for conventional low-pressure or high-pressure duct or for heavy-gauge duct affect the length of the joints and fittings.
- Where necessary, if provided, note on the shop drawing the thickness and type of acoustical lining and external insulation.
- Be aware that duct sizes are usually increased to allow for the thickness of acoustical lining, but plans and specifications should be checked for verification of the designer's intent.
- Refer to layout dimensions regarding approved HVAC equipment submittal cuts.
- Carefully check gauge specifications and types of materials for boiler breechings, exhaust and fume hoods, and kitchen exhaust components.
- Note that watertight duct construction is generally necessary for shower rooms and dishwasher equipment.
- Note that horizontal ducts may be pitched downward slightly to drain connections when run through moist environments.
- Notice that fire and fire/smoke dampers are required to be shown on the HVAC drawings and generally include a note in reference to the applicable installation and material code. Coordinate this information with RFIs and life safety drawings.
- Include a note that requests necessary information from the architect or designer if the location of a fire damper is doubtful.
- Be sure each fire damper is accessible through a properly sized access door for fusible link inspections and maintenance.
- Include additional notes to the attention of the architect or designer if information is necessary to confirm a dimension on the shop drawing in the following cases:
  - When it is not shown on the design or architectural plan
  - When it is necessary to indicate a specific location that is inadequate for duct clearance
  - When work must be done by others
  - When it is necessary to identify locations where coordination of the work with other trades is essential

1.6.0 As-Built Drawings

As-built drawings must be made on alteration or addition jobs, on jobs where modifications must be made to make way for other mechanical trades, or to alter the location of a component. In some cases, particularly on additions or alterations, these drawings may be available from the building or plant engineer. These drawings indicate actual installations by the various mechanical trades and must be used for reference by the drafter when called upon to provide a shop drawing for the modified system or components. As-built drawings usually use dashed lines to indicate ducts, piping, and equipment at close proximity to the work. Separate symbols or notes must be used to distinguish ducts that are to be removed and discarded from those that will be relocated.

The as-built drawings are then placed on the architect's plan (sometimes in another color, such as red), but are more often stamped AS-BUILT. The as-built drawings become a permanent part of the building's drawings. In addition, notes should be made as to the types of connections and existing duct locations that will be reconnected. Duct openings through existing concrete or masonry walls should also be located, checked, and indicated.

On larger projects, the various contractors and subcontractors often maintain their own sets of as-builts. This enables electricians, plumbers, HVAC technicians/installers, and other skilled tradespeople to make changes without holding up the job to locate a single set of plans. At the end of the project, however, all of the sets of as-builts are combined into one comprehensive set that is delivered to the project owner.

As-built drawings are often helpful in several additional ways. The information that they provide about the locations of wiring, plumbing, and other hidden components makes it easier to perform repairs and maintenance. As-builts can also be used as a base when creating remodeling plans for future renovations. In some cases, local governments or permitting agencies may require a copy of the as-builts to show locations of sprinkler pipes, fire alarms, and other safety devices.

1.7.0 Schedules

Schedules are not drawings. They are tables shown on the various drawings throughout the drawing set. These tables identify the types and sizes of items used by the different trades in the construction of a building. Any or all of the following information about an item may be included in a schedule: vendor's name, product name, model number, quantity, size, rough opening size, and color. Placing these details in simple tables keeps the drawings from becoming cluttered and crowded with textual notes.

Each schedule lists information related to a similar group of items, such as doors, windows,

Protection of Underground Facilities

To avoid damage or interruptions to underground utilities caused by digging, it is mandatory to contact the various companies for a utility stakeout prior to any digging. Most states have a One Call Notification System center that makes digging notification easy by calling a single phone number or by contacting the center on the Internet. Typically, the call must be made at least two or three working days before the digging is to begin.

A Dig Safely card and other materials are readily available from state Dig Safely notification centers to remind contractors and excavators of this requirement. Shown here is a Dig Safely card available from the Dig Safely New York notification center. In addition to giving the procedure for contacting the center, it shows the American Public Works Association (APWA) universal color codes used for the temporary marking of underground facilities. All other states have cards similar to the one shown for New York.

FRONT

BACK

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and plumbing fixtures. For example, schedules that identify the windows and doors in a building are shown on the floor plans. Items in the schedules are keyed to the drawing with identification letters, numbers, and symbols. So, on a floor plan, doors may be shown as circles that have a letter inside them, and windows may be shown as hexagons that have a number inside them. The letters and numbers are then keyed to the door and window schedules. For instance, a circle with E inside it on the floor plan is described on the door schedule as a hollow-core, 6-panel door, size 2'-8" × 6'-8"; and a hexagon with 4 inside it on the floor plan is described on the window schedule as an aluminum, single-hung window, size 2'-0" × 4'-0".

Of importance to the HVAC technician are the schedules for the mechanical components and equipment shown on the mechanical plans. Schedules shown on the related plumbing plans and electrical plans may also be relevant to the HVAC technician. *Figure 21* shows schedules typical of those found on mechanical plans.

1.8.0 Request for Information

The request for information (RFI) is used for clarification. If a discrepancy, conflict, or incomplete information is noted on the plans, an RFI may be issued to the architect or engineer. There is a hierarchy that is usually followed. For example, if you notice a discrepancy on the plans, you should notify your immediate supervisor. That will likely be your foreman on a job site. The foreman generates the RFI, being as specific as possible and making sure to put the time, date, and company RFI number on it. The foreman gives the RFI to the superintendent or project manager, who passes it on to the general contractor. The general contractor then relays the RFI to the architect or engineer. A sample RFI form is shown in *Figure 22*. The person who finds a discrepancy on the plans should clearly describe the conflicting information and, if possible, suggest how to correct the problem.

1.9.0 Building Codes

Building codes that are national in scope provide minimum standards to guard the life and safety of the public by regulating and controlling the design, construction, and quality of materials used in modern construction. They have also come to govern use and occupancy, location of a type of building, and the ongoing maintenance of all buildings and facilities. Once adopted by a local jurisdiction, these model building codes then become law. It is common for localities to change or add new requirements to any model code requirements adopted in order to meet more stringent requirements and/or local needs. The provisions of the model building codes apply to the construction, alteration, movement, demolition, repair, structural maintenance, and use of any building or structure within the local jurisdiction.

The model building codes are the legal instruments that enforce public safety in construction of human habitation and assembly structures. They are used not only in the construction industry but also by the insurance industry for compensation appraisals and claims adjustments, and by the legal industry for court litigation.

Up until 2000, there were three model building codes. The three code writing groups, Building Officials and Code Administrators (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI), combined into one organization called the International Code Council (ICC) with the purpose of writing one nationally accepted family of building and fire codes. The first edition of the *International Building Code®* was published in 2000, a second edition was published in 2003, and a third in 2006. It is intended to continue on a three-year cycle. At the time of this writing, 2012 is the latest edition.

In 2002, the National Fire Protection Association (NFPA) published its own building code, *NFPA 5000®*. At the time of this writing, 2012 is the latest edition and the next edition is due in 2015.

Thus, there are now two nationally recognized codes competing for adoption by the 50 states—the *International Building Code®* and *NFPA 5000®*. The format and chapter organization of the two codes differ, but the content and subjects covered are generally the same. Both codes cover all types of occupancies from single-family residences to high-rise office buildings, as well as industrial facilities. They also cover structures, building materials, and building systems, including life safety systems.

When states, counties, and cities adopt a model code as the basis for their own code, they often change it to meet local conditions. They might add further restrictions, or they might adopt only part of the model code. An important general rule to remember about codes is that in almost every case the most stringent local code will apply.

The HVAC technician should be aware of the laws, local building codes, and restrictions that affect the specific job being constructed. This should also include a basic understanding of other codes, such as the NFPA gas and electrical codes.

CABINET UNIT HEATER SCHEDULE

UNIT HEATER NO.	LOCATION	C.F.M.	FAN MOTOR				MBH	GPM	EWT	EAT	MAX. WATER P.D.	REMARKS
			H.P.	VOLTS	PHASE	Hz						
CUH-1	124	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, R.H COIL
CUH-2	137	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, L.H COIL
CUH-3	143	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, R.H COIL

NOTES:
1. 3 Speed Control
2. Front Discharge
3. With Return Air Filters

PUMP SCHEDULE

UNIT NO.	LOCATION	SERVICE.	GPM	MBH	MOTOR					TYPE	REMARKS
					RPM	H.P.	VOLTS	PHASE	Hz		
P-1	MECH. ROOM	NAVE	45	41'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T SERVICE 40% GLYCOL SOLUTION
P-2	MECH. ROOM	CHW TO AHU 1-4	65	37'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T SERVICE 40% GLYCOL SOLUTION
P-3	MECH. ROOM	RECIR. TO TANK	40	17'	1750	1/2	208/230	3	60	IN-LINE	B/G #60-13T SERVICE 40% GLYCOL SOLUTION
P-4	EXIST. MECH. ROOM	HW	73	31'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T HOT WATER

NOTES:
1. Starters And Disconnects By E.C.

GRILLE, REGISTER AND DIFFUSER SCHEDULE

ITEM	MANUFACTURER	MODEL NO.	QTY.	LOCATION	CFM EACH	AIR PATTERN	SIZE		FINISHES	REMARKS
							FRAME	NECK		
A	BARBER COLMAN	SFSV	8	126,127,128 144	245	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	
B	BARBER COLMAN	SFSV	2	142	275	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
C	BARBER COLMAN	SFSV	4	140, 141	240	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	
D	BARBER COLMAN	SFSV	2	139	270	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
E	BARBER COLMAN	SFSV	2	138	280	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
F	BARBER COLMAN	SFSV	2	136	250	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	
G	BARBER COLMAN	SFSV	2	135	235	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	
H	BARBER COLMAN	SFSV	3	134	100	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	FIRE DAMPER SEE DETAIL A
I	BARBER COLMAN	SFSV	1	134	190	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	FIRE DAMPER SEE DETAIL A
		SFSV	1	134						FIRE DAMPER

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Figure 21 Mechanical equipment schedules.

XYZ, Inc
General Contractors
123 Main Street
Bigtown, USA 10001
(111) 444-5555

R.F.I.

Request for Information

XYZ Project # _____
Date: _____
R.F.I. # _____

PROJECT:

RE:

TO:

Specification Reference: _____

Drawing Reference: _____

SUBJECT:

REQUIRED:

Date Information is Required: _____

XYZ, Inc
By: _____

REPLY:

Distribution: Superintendent
Field File

By: _____

Date: _____

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Figure 22 Request for information form.

Fire and Smoke Dampers

It is important when reading drawings to know the difference between fire dampers and fire/smoke dampers. Fire dampers are simple spring-return devices. When the lead fusible link melts at the set temperature (usually about 165°F to 185°F), the damper spring is released and slams closed. These dampers must be manually reset once they are tripped, and a new fusible link installed to hold the spring. These dampers are much lower in cost and do not require any other coordination for installation outside of the sheet metal trade.

Combination fire/smoke dampers include the same components as a fire damper, but add the complexity of motorized control. This damper is also a spring damper, but includes a motor, and must be powered open by a signal from the fire alarm system. If that signal is lost, the spring automatically closes the smoke damper whether or not the fusible link in the fire damper is affected. Smoke dampers can be installed separately from fire dampers, but they cannot be separated by any more distance than allowed by code, which is usually about 2 feet, or two to four duct diameters. Check local codes. The added cost of the smoke damper to a system is significant, as several trades are needed for a completed installation (electrical, controls, sheet metal, and sometimes others). The cost and size of the actual fire/smoke damper impacts all aspects of its installation. The cost of fire/smoke dampers may be four to six times that of fire dampers.

Access to fire/smoke dampers is critical. They must be tested with visual verification of their operation on an annual or semi-annual basis, depending on local fire marshal requirements and recordkeeping.

As-Built Drawings

The specifications for a project typically have a section describing the format or method to use when making as-built drawings for delivery to the general contractor, architect, or owner. Construction changes made by the various contractors as the job progresses are typically marked on a master set of working drawings set aside for this purpose. This marked-up set of drawings forms the basis for the final as-built drawings. The drawing change should be made as soon as possible. Fortunately, CAD technology enables the drawings to be updated more easily. On many jobs, however, any changes to the original design can only be made after a formal document called a change order has been generated and approved by the architect or other designated person.

Additional Resources

Blueprint Reading for Construction, 2003. Second Edition. James A. S. Fatzinger, Upper Saddle River, NJ: Pearson/Prentice Hall.

Reading Architectural Work Drawings, 2003. Sixth Edition. Edward J. Muller and Phillip A. Grau III. Upper Saddle River, NJ: Prentice Hall.

1.0.0 Section Review

1. To find the information that you need, it may be necessary to view several drawings in a set.
   a. True
   b. False

2. Site plans are sometimes called _____.
   a. elevations
   b. sections
   c. plot plans
   d. foundation plans

3. Elements such as the heights of windows, doors, and porches are often shown on which type of drawing?
   a. Floor plan
   b. Riser diagram
   c. Detail drawing
   d. Elevation view

4. The locations where fixtures are installed in a large commercial building are normally shown on what type of plan?
   a. Structural
   b. Floor
   c. Mechanical
   d. Plumbing

5. The shop guides for fabricating duct runs and fittings are known as _____.
   a. cut lists
   b. gaucho documents
   c. detail drawings
   d. blackmore schematics

6. Dashed lines on as-built drawings indicate ducts, piping, and equipment that are _____.
   a. optional items for consideration
   b. at close proximity to the work
   c. no longer functional features
   d. being removed or altered

7. Details about air diffusers, such as size and model number, would generally be found on a _____.
   a. submittal
   b. detail drawing
   c. section drawing
   d. schedule

8. An RFI is used for _____.
   a. authorization
   b. investigation
   c. clarification
   d. modification

9. Model building codes are legal instruments that are not subject to revision.
   a. True
   b. False

SECTION TWO

2.0.0 SPECIFICATIONS AND SUBMITTALS

Objectives

Describe the uses of specifications and submittals in construction projects.

a. Describe specifications and their purpose.
b. Describe submittals and their purpose.

Trade Terms

Change order: The documentation of a change management process, where changes in the Scope of Work that were originally agreed to by owner(s), contractor(s), and architects or engineer are recorded. Typically, the order is related to additions or deletions from the Scope of Work, and alters the completion date and/or the contract value.

Specifications and submittals perform interrelated roles in new construction projects. Specifications are formatted to spell out the exact standards for the work to be done and the materials and equipment to be used. If project specifications call for special pieces of equipment or accessories to be furnished and installed by the subcontractor, a submittal document must be provided for such items.

2.1.0 Specifications

Specifications are written statements provided by the architectural and engineering firm to the general contractor and, consequently, to the subcontractors. Specifications define the quality of work to be done and describe the materials to be used. They are very important to the architect and owner because they guarantee compliance by the contractors to the standards set for the project. Specifications consist of various elements that may differ somewhat for particular construction projects. An example of the abbreviated specifications for a hypothetical construction project is provided in *Appendix B*. The example in the appendix follows the specification-writing format developed by the Construction Specifications Institute (CSI).

2.1.1 Purpose

Specifications have several important purposes, such as the following:

- They clarify information that cannot be shown on the drawings.
- They identify the work standards, types of materials to be used, and responsibilities of various parties to the contract.
- They provide information on details of construction.
- They serve as a guide for contractors bidding on the construction job.
- They serve as a standard of quality for materials and workmanship.
- They serve as a guide for compliance with building codes and zoning ordinances.
- They serve as the basis of agreement between the owner, architect, and contractors in settling any disputes.

There are two types of information contained in a set of specifications: non-technical (special and general conditions) and technical aspects of construction.

2.1.2 Special and General Conditions

Special and general conditions cover the non-technical aspects of the contractual arrangements. Special conditions cover topics such as safety, temporary construction, shop drawing(s) required, and so on. General conditions cover the following points of information:

- Contract terms
- Responsibilities for examining the construction site
- Types and limits of insurance
- Permits and payment of fees
- Use and installation of utilities
- Supervision of construction
- Other pertinent items

Notes on Drawings

Sometimes notes on drawings contradict written specifications or are inconsistent with other requirements. Even though the specifications usually take precedence, the notes are often closer to the true intent. In any case, initiate an RFI to clarify such a discrepancy when you see it.

The general conditions section is the area of the construction contract where misunderstandings often occur. Therefore, these conditions are usually much more explicit on large, complicated construction projects.

2.1.3 Technical Aspects

The technical aspects section of the specifications covers the work to be done by the major divisions and identifies the standards for each part. The divisions are usually in the order in which the work will be performed; for example, site work is listed before carpentry work.

The technical aspects section includes information on materials that are specified by standard numbers and by standard national testing organizations, such as the American Society of Testing Materials (ASTM) International. The specifications are usually written around some standard format published by the American Institute of Architects (AIA).

2.1.4 Format

For convenience in writing, speed in estimating work, and ease in reference, the most suitable organization of the specifications is a series of sections dealing successively with the different trades. All the work of each trade should be incorporated into the section devoted to that trade. Those people who use the specifications must be able to find all needed information quickly.

The most commonly used specification-writing format in North America is the MasterFormat™. This standard was developed jointly by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC). For many years prior to 2004, the organization of construction specifications and suppliers catalogs was based on a standard with 16 sections, otherwise known as divisions, where the divisions and their subsections were individually identified by a five-digit numbering system. The first two digits represented the division number and the next three individual numbers represented successively lower levels of breakdown. For example, the number 13213 represents division 13, subsection 2, sub-subsection 1 and sub-sub-subsection 3. In this older version of the standard, all things related to the HVAC systems were lumped together under Division 15 – Mechanical. In construction and on drawings, HVAC systems are often referred to as the mechanical systems; thus the term mechanical contractor. Today, some specifications conforming to the 16-division format may still be in use. The older version of the standard contains the following divisions:

- *Division 1* – General Requirements
- *Division 2* – Site Work
- *Division 3* – Concrete
- *Division 4* – Masonry
- *Division 5* – Metals
- *Division 6* – Wood and Plastics
- *Division 7* – Thermal and Moisture Protection
- *Division 8* – Doors and Windows
- *Division 9* – Finishes
- *Division 10* – Specialties
- *Division 11* – Equipment
- *Division 12* – Furnishings
- *Division 13* – Special Construction
- *Division 14* – Conveying Systems
- *Division 15* – Mechanical
- *Division 16* – Electrical

In 2004, the MasterFormat™ standard underwent a major change. The 16 original divisions were expanded to four major groupings and 49 divisions (50 if Division 00 – Procurement and Contracting Requirements is counted) with some divisions reserved for future expansion. The first 14 divisions are essentially the same as the old format. Subjects under the old Division 15 – Mechanical have been relocated to new divisions 21, 22, and 23. In addition, the numbering system was changed to 6 digits to allow for more subsections in each division for finer definition. Updates to the MasterFormat™ standard were made in 2010 and 2012 with minor effects on the divisions that were introduced in 2004. At the time of this writing, the 2012 update of the standard remains the most recent one.

2.2.0 Submittals

Submittals are documents that illustrate special pieces of equipment or accessories that are to be furnished and installed by the subcontractor. The

Addenda and Change Orders

Addenda and change orders are contractual documents used to correct or make changes to original construction drawings and specifications. The difference between the two documents is a matter of timing. An addendum is written before and a change order is drawn up after the contract is awarded.

submittal document is received from the equipment or accessory supplier by the subcontractor, and then submitted to the general contractor after the bid has been accepted and the contract signed. Subcontractors receive submittals for any major pieces that they are contractually obligated to install. The information from the submittals is used as a resource to complete submittal sheets.

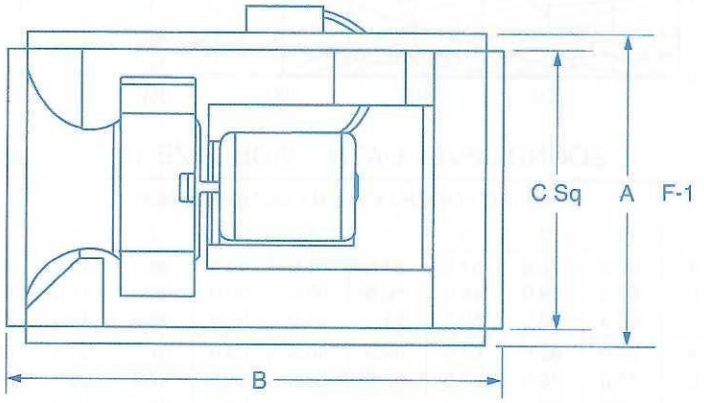
The submittal sheet (*Figure 23*) illustrates the accessory or piece of equipment that has been defined in the specifications and that must conform to the standards as outlined in the specifications manual.

Permits

Always make sure you have all the required permits before beginning an installation task. Failure to do so can result in increased costs and lost profits for your employer. This is because the laws in some states give owners the right to refuse payment for any work that is done prior to receiving the proper permits to perform that work. Some states also require that changes to a project be formally documented by an approved change order prior to beginning work on the change. A revised permit may also be required.

SUBMITTAL SHEET HV 4-8
IN LINE CENTRIFUGAL DUCT FANS

MODEL VIDB – DIRECT DRIVE



UNIT SIZE	A	B	C	INLET OR OUTLET AREA	WHEEL DIAMETER	WT (lbs)
06	13⅞"	20"	12"	0.979 sq ft	10¾"	30
08	13⅞"	20"	12"	0.979 sq ft	10¾"	40
10	13⅞"	20"	12"	0.979 sq ft	10¾"	40
12	17⅞"	27⅜"	16"	1.750 sq ft	11 13/16"	75
15	*21⅞"	31"	20"	2.740 sq ft	14⅞"	90
18	*21⅞"	33⅜"	26"	4.650 sq ft	17 13/16"	140

* A-1 Larger on access door sides

JOB NAME AND LOCATION	SUBMITTED BY
SECTION 15000 2.4.1	

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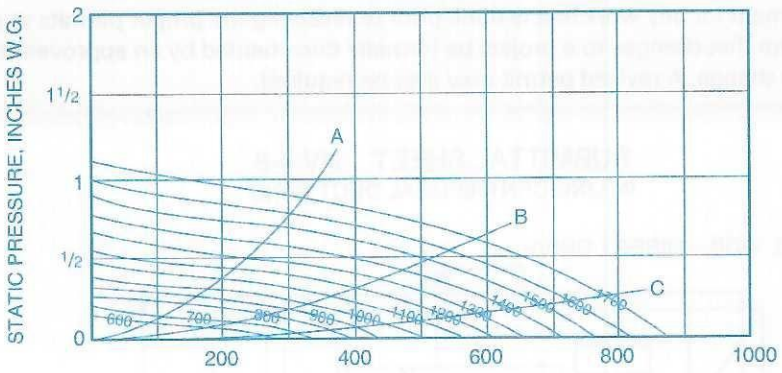
Figure 23 Submittal sheet (1 of 2).

SUBMITTAL DATA TYPE VIDB IN LINE DUCT FANS

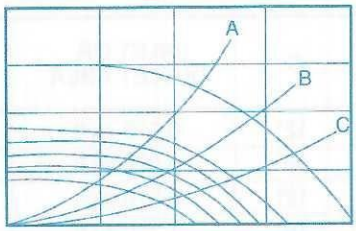
MODEL VIDB 10 – DIRECT DRIVE UNITS

SIZE 10	MOTOR HP	RPM	TIP SPEED	STATIC PRESSURE, INCHES W.G. ⅛ CFM	¼ CFM	⅜ CFM	½ CFM	⅝ CFM	¾ CFM	1 CFM
10-D3S with ES60 Speed Control	35 MHP Standard Motor	700	1970	200						
		800	2250	295						
		900	2535	365	160					
		1000	2815	430	290					
	100W Max.									



SOUND LEVEL DATA VIDB SIZE 10

SIZE RPM	*	SOUND POWER LEVEL BY OCTAVE BANDS 1	2	3	4	5	6	7	8	LWA	SONE
10-10D 1105	A	62.5	72.5	57.5	54.5	51.0	49.5	48.0	47.0	60.5	5.6
	B	62.5	69.0	58.0	56.5	53.5	50.0	48.0	47.0	60.0	5.2
	C	62.5	68.0	59.0	58.5	57.0	51.5	48.5	47.0	62.0	5.5
10-10H 1710	A	72.0	82.0	67.0	64.0	60.5	59.0	57.5	56.5	69.5	10.7
	B	72.0	78.5	67.5	66.0	63.0	59.5	57.0	56.5	69.5	9.8
	C	72.0	77.5	68.5	68.0	67.0	61.0	58.0	56.5	71.0	10.0



PROJECT: AGENT:

SUBMITTAL DATE: JOB NO:

The CARNES Company
Manufactured Products

DRAWING NO:

Date: Rev:

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Figure 23 Submittal sheet (2 of 2).

For example, the specifications for an in-line centrifugal duct fan may have been stated as follows:

> "Centrifugal in-line duct fans shall be ACME Company, Model VIDB direct drive or Model VIBA belt drive, as shown on the plans and schedules. Fans shall be constructed of heavy-gauge steel and electro-coated acrylic enamel finish over iron phosphate primer. Wheels 12 inches in diameter and larger shall have median foil blades to assure quiet, efficient operation. The motor drive compartment shall be isolated

from the airstream and externally ventilated. Bearings shall be pre-lubricated and sealed for minimum maintenance and designed for 200,000 hours of operation. Internal parts (wheels, shaft, bearings, motor, and drive) shall be accessible for inspection and repair or replacement without disturbing inlet or outlet ductwork. Fans shall be furnished with a mounted safety disconnect. Single-phase motors shall have integral overload protection. V-belt drives shall be adjustable. Horsepower and noise levels shall not exceed the values shown, and oversized motors will not be acceptable. Performance ratings shall be certified for air and sound."

The submittal is commonly used to describe the unit specified by the architect or engineer.

If the specification allows for substitutions, however, the subcontractor may choose an alternate piece of equipment. In that case, a submittal for the new equipment is acquired by the subcontractor, who submits copies of it to the general contractor, who then submits it to the owner, architect, and any code enforcement authorities. These people either accept or reject the submittal. If the submittal is accepted by the general contractor, owner, and architect, the item may then be installed, as agreed upon, by the subcontractor.

The submittal sheet, as shown, includes the pertinent information that meets the specifications for the construction project. It includes such information as the size of the unit and rough opening, the specifications relating to the size of the inlet or outlet, the cubic feet per minute (cfm), and the sound ratings. The type of mounting may also be stated along with any accessories that would be applicable, such as electronic speed control, spark-resistant wheels, and explosion-proof motors.

When agreed upon by all, the submittal contains the genuine specifications for the unit or accessory with no deviations without approval by a **change order** from all parties.

Submittal drawings, which are considered a type of shop drawing, are typically the responsibility of equipment and accessory manufacturers.

Specifications

Written specifications supplement the related working drawings in that they contain details not shown on the drawings. Specifications define and clarify the scope of the job. They describe the specific types and characteristics of the components that are to be used on the job and the methods for installing some of them. Many components are identified specifically by the manufacturer's model and part numbers. This type of information is used to purchase the various items of hardware needed to accomplish the installation in accordance with the contractual requirements.

Making Submittals

When making submittals, make enough copies so that at least one copy of the original is available as an office file copy. It is common for contractors to scan submittal documents and store them in an electronic file. A log book in which each submittal is recorded should be kept by the submitting contractor. As a minimum, the log entries should include the name of the recipient, name of the submittal item(s), the date submitted, and the section of the specification that applies. All submittals should clearly show the company name so that an approved submittal can be returned to that organization. When an approved submittal is received, the date received should be noted in the submittal log, and the approved copy should be filed in a safe location. If the company has subcontracted work to other contractors (such as an air and water balance contractor), it is usually necessary that copies of the applicable approved submittals be provided to the subcontractor for incorporation into the subcontractor's work.

Additional Resources

Blueprint Reading for Construction, 2003. Second Edition. James A. S. Fatzinger, Upper Saddle River, NJ: Pearson/Prentice Hall.

Construction Specifications Writing: Principles and Procedures, 2010. Sixth Edition. Mark Kalin, Robert S. Weygant, Harold J. Rosen, and John R. Regener. Hoboken, NJ: John Wiley & Sons, Inc.

Reading Architectural Work Drawings, 2003. Sixth Edition. Edward J. Muller and Phillip A. Grau III. Upper Saddle River, NJ: Prentice Hall.

2.0.0 Section Review

1. Specifications serve as a basis for settling disputes when the owner, architect, and contractors disagree about the details of a construction project.
   a. True
   b. False
2. To obtain approval for making an alteration to a piece of equipment for which the specifications do not allow for substitutions and a submittal has been agreed upon, you must _____.
   a. petition the appropriate code enforcement authorities
   b. use a change order to get approval from all parties
   c. consult with the owner and architect for the project
   d. request authorization from the general contractor

SECTION THREE

3.0.0 TAKEOFFS

Objectives

Describe the takeoff process and how it is performed.

a. Identify and describe the tools and materials used in the takeoff process.
b. Explain how to conduct a takeoff.

Performance Task 6

6. Perform an HVAC equipment and material takeoff and prepare the takeoff forms.

Trade Terms

Takeoff: The process of surveying, measuring, itemizing, and counting all materials and equipment needed for a construction project, as indicated by the drawings.

The takeoff procedure involves surveying, measuring, and counting all materials and equipment indicated on a set of drawings. Although there are many sophisticated software programs available today to help the process, they are best used for large projects and by someone who is skilled at the takeoff process in general. Therefore, it is best to learn and experience the takeoff process using manual methods first.

3.1.0 Takeoff Tools and Materials

Open standard takeoff sheets are available for the HVAC technician to use for accurate takeoffs. The sheets are useful because they provide standardization, continuity, and a permanent record. In addition, they reduce the workload as well as the potential for error.

There are several types of takeoff sheets available for use by the HVAC contractor. These sheets include the following:

- *Air devices and equipment takeoff sheets* – These are usually 8½" × 11" standard sheets. They are ruled in four columns, with room to indicate the item number, the classification of the equipment, the quantity, and any necessary remarks.
- *Piping and accessories takeoff sheets* – These often include individual sheets for pipe (*Figure 24*), fittings (*Figure 25*), valves (*Figure 26*), hangers (*Figure 27*), and strainers, traps, and joints.
- *Ductwork takeoff sheets* – The information required includes duct size and length, area per foot of run, total area of duct, maximum duct size, and suggested gauge (*Figure 28*).

The following materials will make the measuring, counting, and calculating tasks easier:

- Colored pencils for checking off items on drawings as they are taken off. The same color can be used for all the material contained within a system to simplify following up on that system.
- An automatic mechanical counter for counting similar diffusers, grilles, and registers
- An electronic wheel scaler or similar device for measuring duct and piping runs (should have scales of ⅛", ¼", and ½")
- Metallic tape with ⅛" scale on one side and a ¼" scale on the other for measuring duct and piping runs
- Two drafting scales (one architect's and one engineer's)
- An adding machine or calculator
- A magnifying glass for examining details on the drawings
- A large collection of manufacturers' catalogs, technical books and manuals, and previous job files for reference

PROJECT NAME _____ JOB NO _____

PIPING SYSTEM _____ MATERIAL _____

PIPE SIZES (MEASURED IN INCHES)							
FEET	NUMBER OF JOINTS	FEET	NUMBER OF JOINTS	FEET	NUMBER OF JOINTS	FEET	NUMBER OF JOINTS
TOTAL							

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Figure 24 Piping takeoff sheet.

PROJECT NAME _____ JOB NO _____

MATERIAL _____ CLASS _____

FITTING TYPE	FITTING SIZES (MEASURED IN INCHES)						
NO. OF JOINTS							

03401-12_F25.EPS

Figure 25 Piping fitting takeoff sheet.

PROJECT NAME _____ JOB NO _____

MATERIAL _____ CLASS _____

TYPE OF VALVE DEVICE	VALVE AND DEVICE SIZES (MEASURED IN INCHES)						

03401-13_F26.EPS

Figure 26 Valve takeoff sheet.

PROJECT NAME _____ JOB NO _____

HANGER TYPE	PIPE SIZES (MEASURED IN INCHES)						

03401-13_F27.EPS

Figure 27 Hanger takeoff sheet.

PROJECT NAME _____ JOB NO _____

DUCTWORK SYSTEM _____ MATERIAL _____

DUCT SIZE (INCHES)	DUCT SIZE (FEET)	SQ. FT. PER FT. OF RUN	TOTAL AREA OF DUCT (SQUARE FEET)				
			MAXIMUM DUCT SIZE AND SUGGESTED GAUGE				

03401-13_F28.EPS

Figure 28 Ductwork takeoff sheet.

After the takeoff is complete, record all material and equipment classifications on the job estimating sheets and copy the total quantity of each item as it appears on the takeoff sheets to the job estimating sheets.

The drawings and specifications are used to identify the types and quantities of equipment and materials required for the project. The selection of heating, ventilating, and air conditioning (HVAC) equipment is based on an analysis of heating and cooling loads performed by the architect or engineer. The purpose of the analysis is to select the equipment that is physically suited to the structure and is sized to meet its heating and cooling loads and air flow requirements. Load estimating and equipment selection are explained in a later module.

The selection of materials for HVAC systems is based on a study of the conditions of operation. The factors to consider include the following:

- Code requirements.
- The working fluid in the piping system.
- The pressure and temperature of the fluid.
- The environment around the pipe.
- The budget for the installed system.

Piping, ductwork, pipe/duct hangers and supports, and valves are also selected from the drawings and specifications. An overview of the criteria that go into the selection process for these items is provided in the sections that follow.

3.2.0 Takeoff Procedures

In an HVAC takeoff, the materials and equipment should be taken off in the following order:

1. Equipment such as boilers, chillers, pumps, air-handing units, fans, and air cleaners
2. Air devices and air terminals
3. Radiant heating system components
4. Piping and accessory systems
5. Ductwork, dampers, and louvers
6. Insulation for piping, ductwork, and equipment
7. Gauges and thermometers
8. Motor starters, motor control centers, and electrical work to be furnished by the HVAC contractor
9. Temperature control systems
10. Other special systems to be furnished and installed by the HVAC contractor

The takeoff procedure for valves, fittings, piping, hangers, and accessories is as follows:

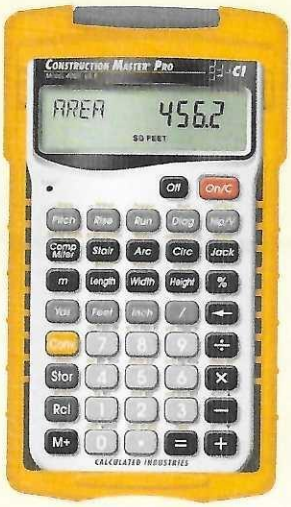
Step 1 Prepare the required takeoff sheets.

Step 2 Read the specifications carefully; then list the materials and joints specified for each system.

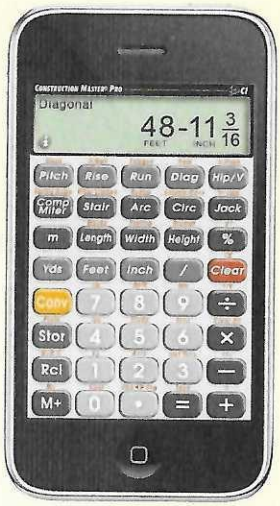
Construction Calculators

Using construction calculators to project the cost and time required to complete a project can help save time and money. These calculators are equipped with built-in solutions for completing plans, layouts, bids, and estimates. They allow you to set and store preferences and format essential calculations (stair clearance, roof pitch, framing, circular calculations, etc.) for dimensions that are frequently required or established by codes. Typically, construction calculators like the one shown here work in and convert between feet-inches-fractions and decimals, including metric. To ensure accurate estimates, you must periodically adjust the calculator based on known changes in the project.

As shown in the example, many construction calculators, are also available as applications that can be installed on mobile phones or tablets.



CALCULATOR



MOBILE PHONE APPLICATION

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Step 3 Take off each system as indicated on the floor plans, section details, and flow diagrams. The takeoff must include piping, fittings, valves, joints, hangers, and all accessories.

Step 4 List all quantities of the same size in one column of the takeoff sheet.

Step 5 Measure pipe lengths in feet; count the fittings, valves, hangers, and so on.

Step 6 After completing the takeoff, add the quantities of each size, and transfer the sum to a master sheet.

The takeoff procedure for ductwork follows:

Step 1 Use a standard takeoff sheet or prepare one.

Step 2 Read the specifications; then list the types of materials, recommended construction, and specified gauges for each system.

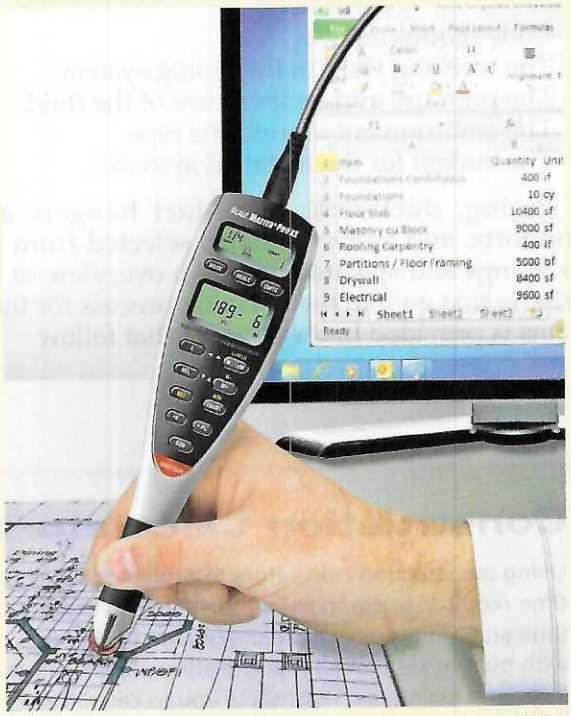
Step 3 Include all the takeoff quantities for all the duct runs that have the same material, construction, acoustic lining, and insulation on one takeoff sheet.

Step 4 Take off each system as indicated on the drawings.

Step 5 Place all the findings on a summary sheet.

Scaling Drawings

Measuring the length of pipe and duct runs on mechanical plans and converting the measurements to actual length using the given scale is called scaling a drawing. Scaling a drawing is commonly done using architect's scales. The task of scaling a drawing when doing a takeoff can be made easier by using an electronic plan wheel scaler like the one shown. Upon input of the scale parameters, this digital plan wheel gives a direct readout of actual length for the scaled distance.



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Additional Resources

Blueprint Reading for Construction, 2003. Second Edition. James A. S. Fatzinger, Upper Saddle River, NJ: Pearson/Prentice Hall.

Reading Architectural Work Drawings, 2003. Sixth Edition. Edward J. Muller and Phillip A. Grau III. Upper Saddle River, NJ: Prentice Hall.

3.0.0 Section Review

1. Types of fittings are usually included in a piping takeoff sheet.
   a. True
   b. False
2. What is the first step in a quantity takeoff procedure?
   a. Read the specifications
   b. List all quantities to be counted
   c. Prepare the required takeoff sheet(s)
   d. Transfer the sum to a master sheet

SUMMARY

Construction drawings and specifications for the HVAC trade contain the information necessary for the layout, fabrication, and installation of duct runs, HVAC piping, and fittings. Specifications are written descriptions of technical design and performance information that must be used when selecting and installing equipment, systems, and construction components. When there is a conflict between the design specifications and the architectural plans, the specifications that are most stringent usually apply. Often the contract or specification will define which document prevails in case of a conflict. Sometimes which document prevails is determined by all parties at the contract signing.

Review Questions

1. You can find the date of the last revision for a set of drawings by looking at the _____.
   a. index
   b. title block
   c. site plan
   d. submittal

2. Site plans may include some construction features such as _____.
   a. pitches of roofs
   b. water supply lines
   c. curbs and gutters
   d. ductwork layout

3. The distance between the centers of the north window and door in the garage shown on the floor plan in *Review Question Figure 1* is _____.
   a. 6'-0"
   b. 6'-4"
   c. 8'-0"
   d. 10'-0"

4. How many roof drains are called for in the roof plan shown in *Review Question Figure 2*?
   a. Three
   b. Four
   c. Five
   d. Six

5. The vertical mansard (type of roof) shown in the elevation drawing on *Review Question Figure 3* is made of _____.
   a. 26 gauge, Type SR arctic white metal
   b. 26 gauge, Type SS arctic white metal
   c. 8" vertical score block
   d. 8" split rib block

6. In accordance with the plumbing plan shown in *Review Question Figure 4*, how many urinals must be installed?
   a. One
   b. Two
   c. Four
   d. Six

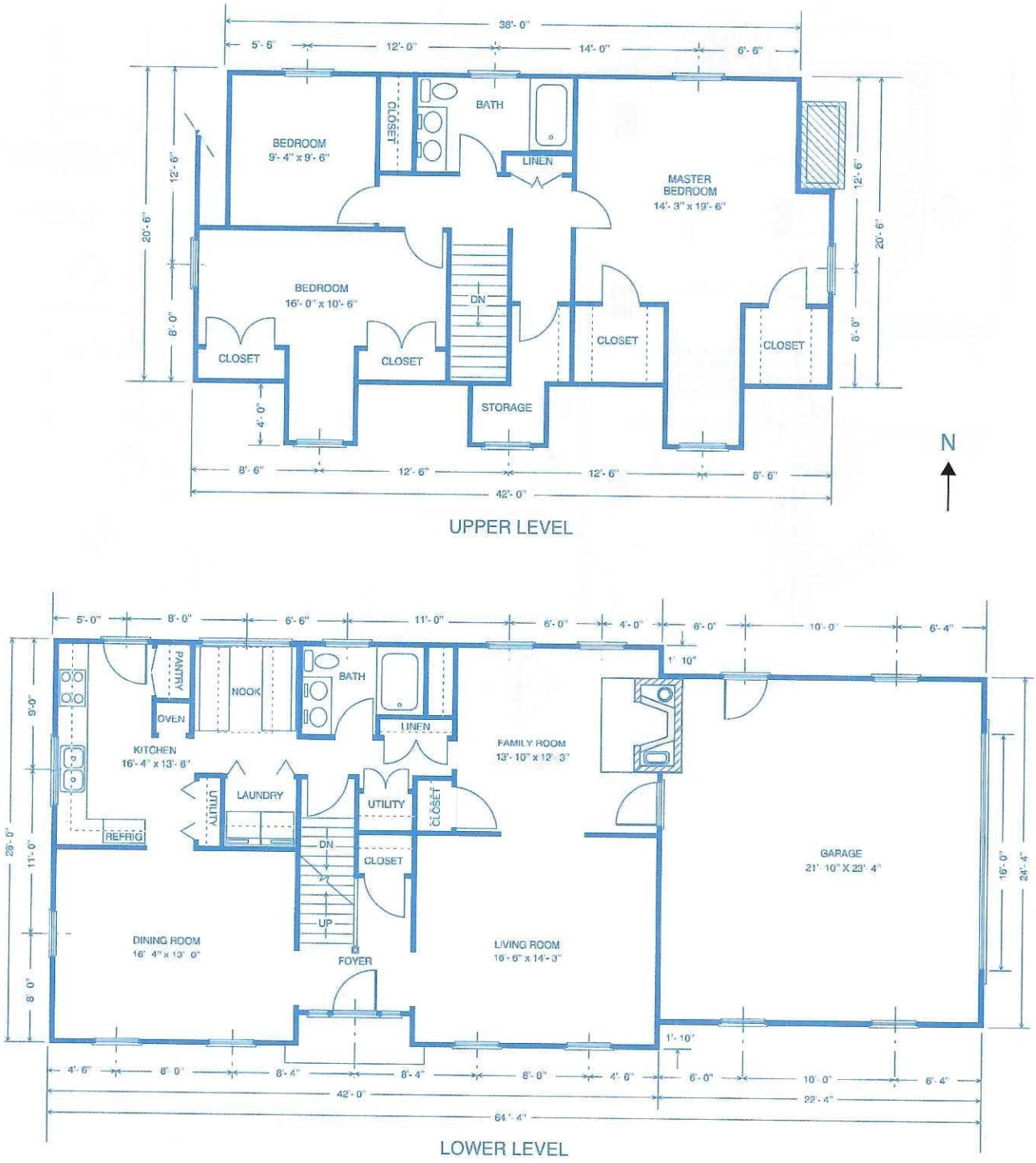


Figure 1

03401-13_RQ01.EPS

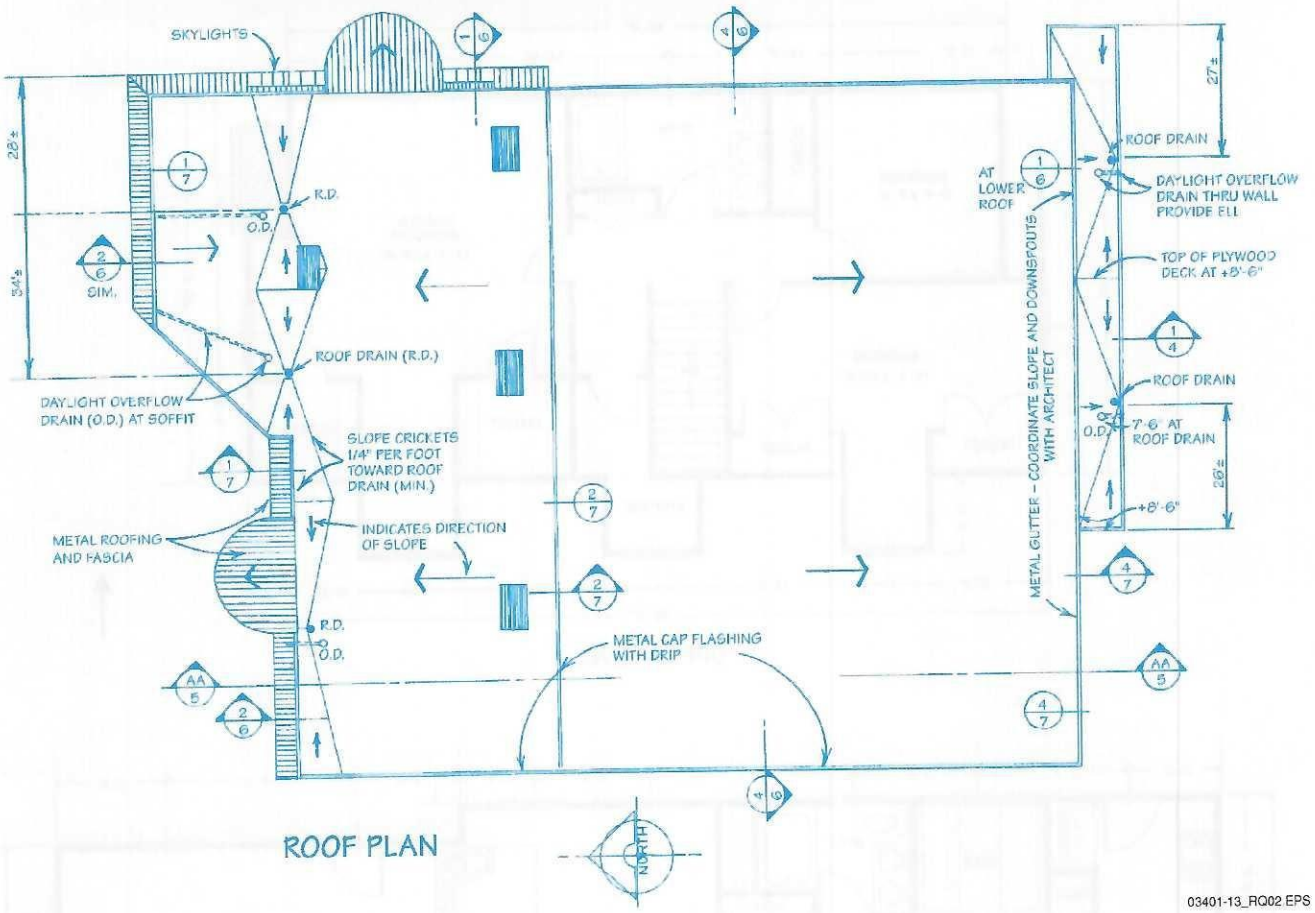

SKYLIGHTS
28'±
54'±
R.D.
O.D.
SIM.
ROOF DRAIN (R.D.)
DAYLIGHT OVERFLOW DRAIN (O.D.) AT SOFFIT
SLOPE CRICKETS 1/4" PER FOOT TOWARD ROOF DRAIN (MIN.)
INDICATES DIRECTION OF SLOPE
METAL ROOFING AND FASCIA
R.D.
O.D.
METAL CAP FLASHING WITH DRIP
AT LOWER ROOF
ROOF DRAIN
DAYLIGHT OVERFLOW DRAIN THRU WALL PROVIDE ELL
TOP OF PLYWOOD DECK AT +8'-6"
METAL GUTTER - COORDINATE SLOPE AND DOWNSPOUTS WITH ARCHITECT
27'±
ROOF DRAIN
O.D.
7'-6" AT ROOF DRAIN
26'±
+8'-6"
NORTH
ROOF PLAN
03401-13_RQ02.EPS

Figure 2

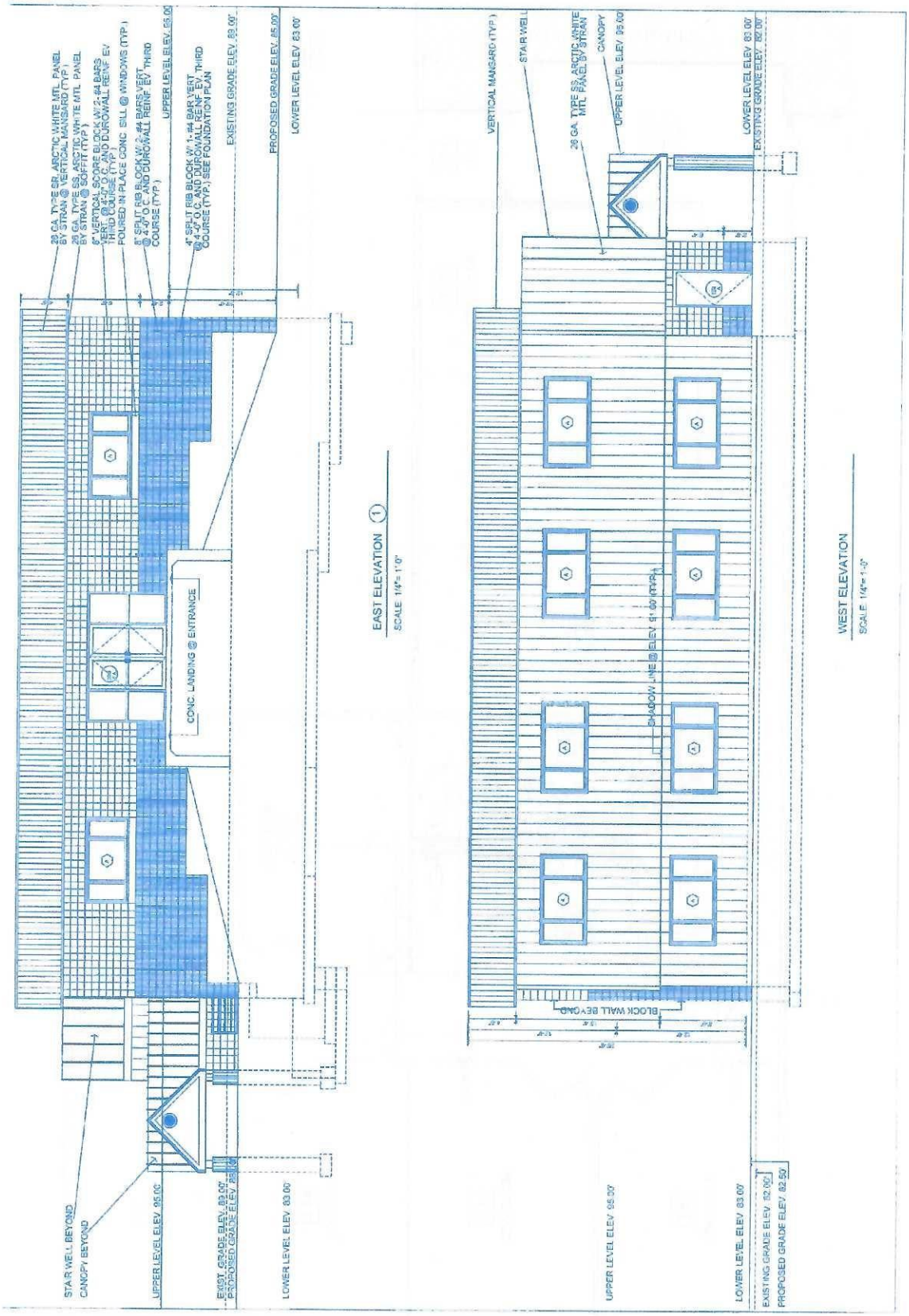

EAST ELEVATION
SCALE 1/4"= 1'0"
WEST ELEVATION
SCALE 1/4"= 1'-0"
CONC. LANDING @ ENTRANCE
BLOCK WALL BEYOND
STAIR WELL BEYOND
CANOPY BEYOND
UPPER LEVEL ELEV. 95.00'
LOWER LEVEL ELEV. 83.00'
EXISTING GRADE ELEV. 83.00'
PROPOSED GRADE ELEV. 82.50'
03401-13_RQ03.EPS

Figure 3

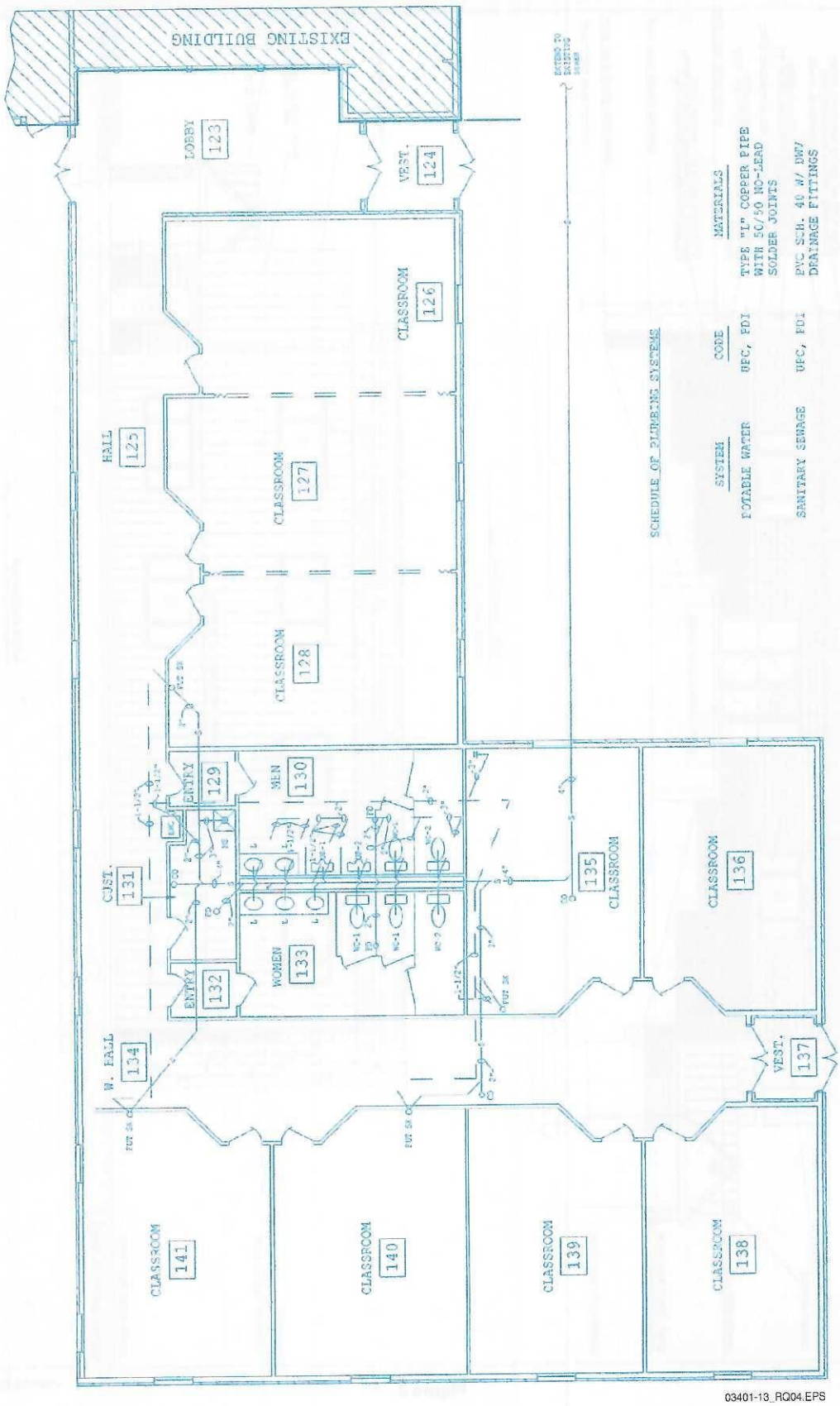

EXISTING BUILDING
LOBBY 123
VEST. 124
CLASSROOM 126
HALL 125
CLASSROOM 127
CLASSROOM 128
ENTRY 129
MEN 130
CUST. 131
ENTRY 132
WOMEN 133
W. HALL 134
135 CLASSROOM
CLASSROOM 136
VEST. 137
CLASSROOM 141
CLASSROOM 140
CLASSROOM 139
CLASSROOM 138
SCHEDULE OF PLUMBING SYSTEMS
SYSTEM
CODE
MATERIALS
POTABLE WATER
UPC, FDI
TYPE "L" COPPER PIPE WITH 50/50 NO-LEAD SOLDER JOINTS
SANITARY SEWAGE
UPC, FDI
PVC SCH. 40 W/ DWV DRAINAGE FITTINGS
03401-13_RQ04.EPS

Figure 4

7. Piping for natural gas is typically shown on the _____.
   a. floor plan
   b. elevation drawings
   c. HVAC drawings
   d. plumbing drawings

8. What size chilled-water supply piping should be connected to Air Handling Unit 1 shown in the mechanical plan on *Review Question Figure 5*?
   a. 1¼"
   b. 1½"
   c. 2"
   d. 2½"

9. The electrical plan in *Review Question Figure 6* shows the new power distribution panel, Panel D, to be installed in _____.
   a. hallway 125
   b. lobby 123
   c. room 126
   d. room 131

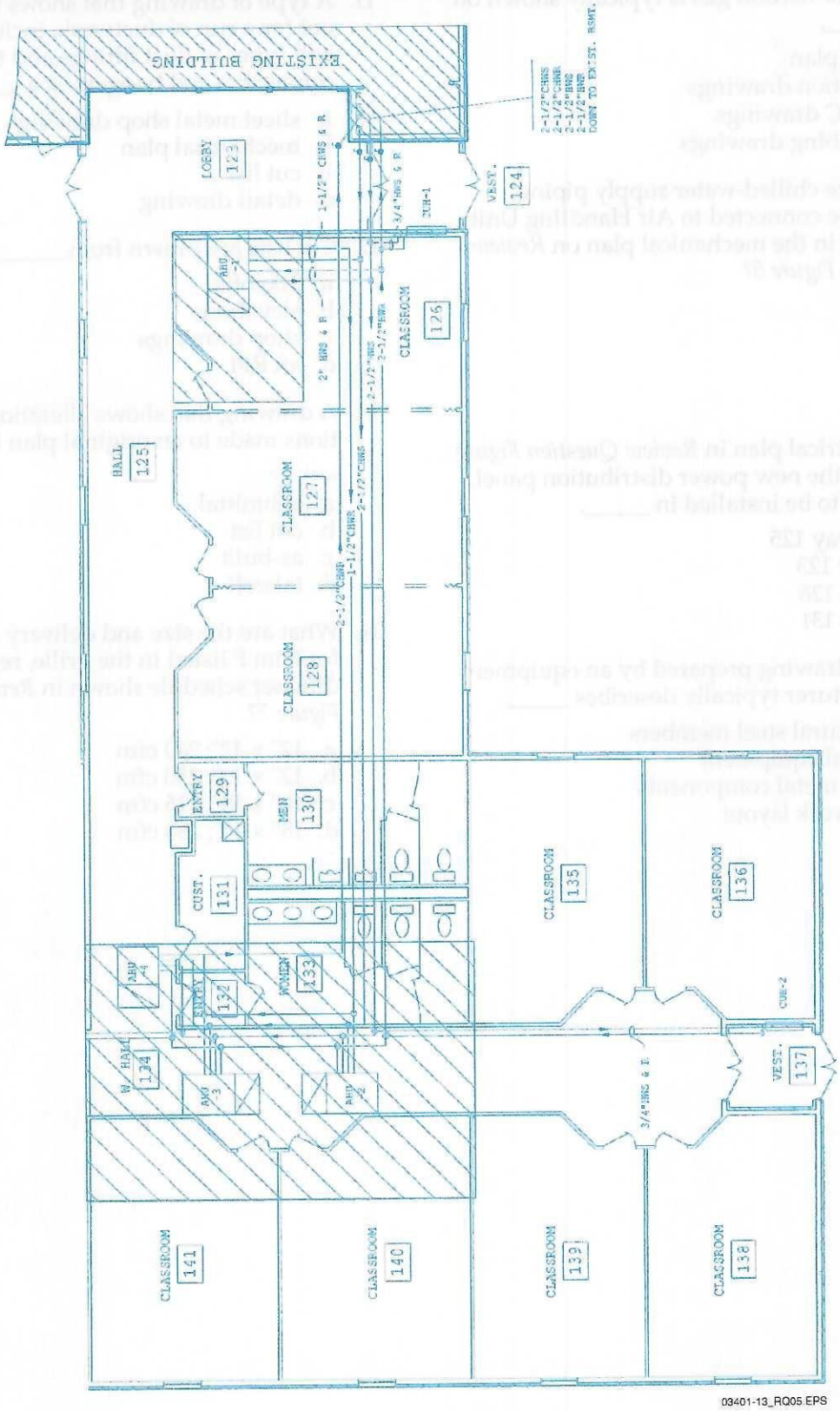
10. A shop drawing prepared by an equipment manufacturer typically describes _____.
    a. structural steel members
    b. special equipment
    c. sheet metal components
    d. ductwork layout

11. A type of drawing that shows the exact layout for a run of ductwork, including the sizes and types of duct fittings and the types of connectors and hangers, is a _____.
    a. sheet metal shop drawing
    b. mechanical plan
    c. cut list
    d. detail drawing

12. Cut lists are drawn from _____.
    a. takeoffs
    b. elevations
    c. shop drawings
    d. an RFI

13. A drawing that shows alterations or additions made to an original plan is called a(n) _____.
    a. submittal
    b. cut list
    c. as-built
    d. takeoff

14. What are the size and delivery specifications for Item F listed in the grille, register, and diffuser schedule shown in *Review Question Figure 7*?
    a. 12" × 12"; 240 cfm
    b. 12" × 12"; 250 cfm
    c. 18" × 18"; 235 cfm
    d. 18" × 18"; 280 cfm



03401-13_RQ05.EPS

Figure 5

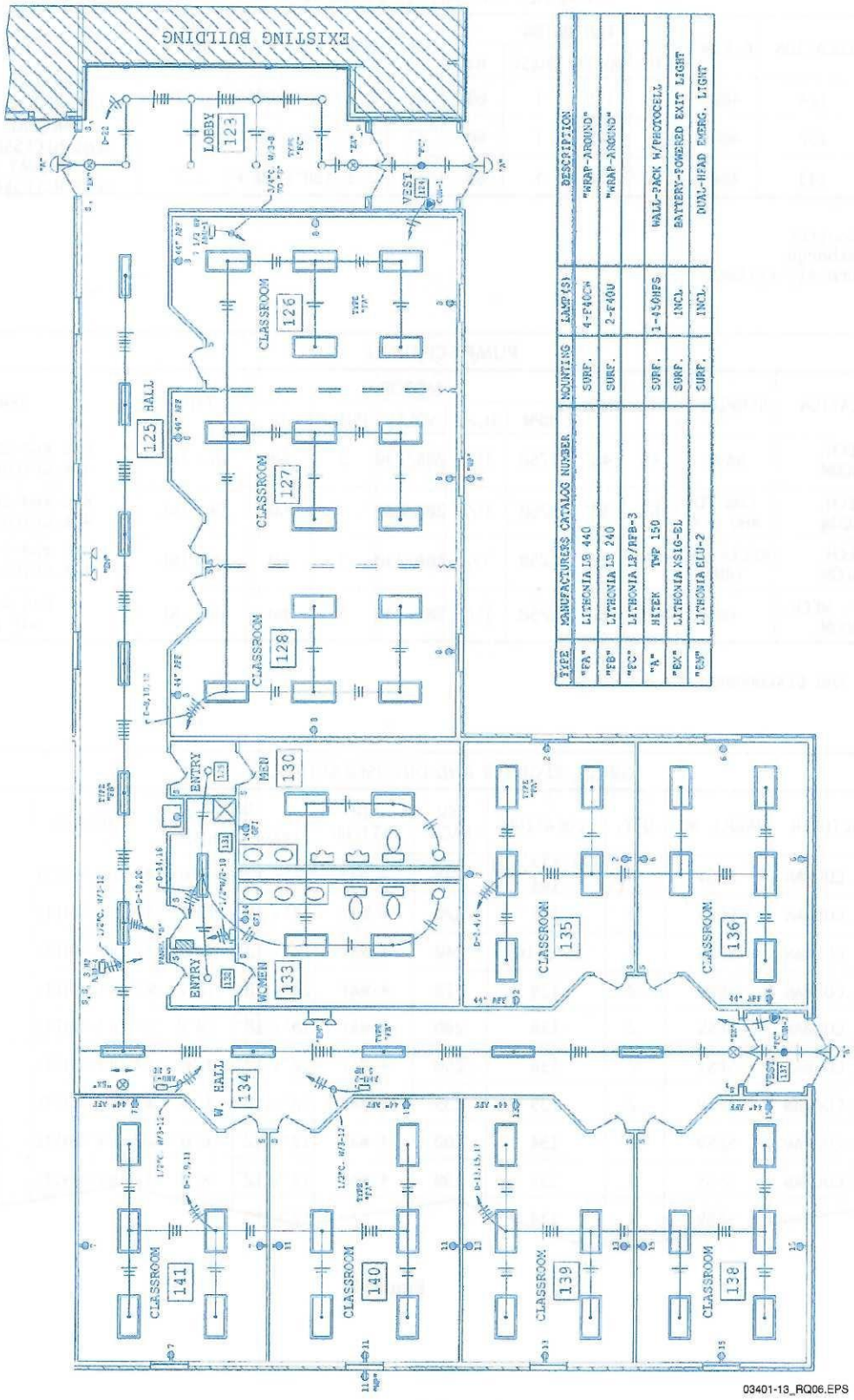

EXISTING BUILDING
LOBBY 123
VEST. 124
CLASSROOM 126
HALL 125
CLASSROOM 127
CLASSROOM 128
ENTRY 132
MEN 130
ENTRY 133
WOMEN 133
CLASSROOM 135
CLASSROOM 136
W. HALL 134
VEST. 137
CLASSROOM 141
CLASSROOM 140
CLASSROOM 139
CLASSROOM 138
TYPE | MANUFACTURERS CATALOG NUMBER | MOUNTING | LAMP(S) | DESCRIPTION
"FA" | LITHONIA IB 440 | SURF. | 4-F40CW | "WRAP-AROUND"
"FB" | LITHONIA IB 240 | SURF. | 2-F40U | "WRAP-AROUND"
"FC" | LITHONIA LF/RFB-3 | | | WALL-PACK W/PHOTOCELL
"A" | HITEK TWP 150 | SURF. | 1-150HPS | BATTERY-POWERED EXIT LIGHT
"EX" | LITHONIA XS1G-BL | SURF. | INCL. | DUAL-HEAD EMERG. LIGHT
"EM" | LITHONIA ELU-2 | SURF. | INCL.
03401-13_RQ06.EPS

Figure 6

CABINET UNIT HEATER SCHEDULE												
UNIT HEATER NO.	LOCATION	C.F.M.	FAN MOTOR				MBH	GPM	EWT	EAT	MAX. WATER P.D.	REMARKS
			H.P.	VOLTS	PHASE	Hz						
CUH-1	124	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, R.H COIL
CUH-2	137	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, L.H COIL
CUH-3	143	400	1/12	115	1	60	23	2.3	180°F	60°F	2.7	McQUAY #CHF004 SEMI-RECESSED, R.H COIL

NOTES:
1. 3 Speed Control
2. Front Discharge
3. With Return Air Filters

PUMP SCHEDULE											
UNIT NO.	LOCATION	SERVICE.	GPM	MBH	MOTOR					TYPE	REMARKS
					RPM	H.P.	VOLTS	PHASE	Hz		
P-1	MECH. ROOM	NAVE	45	41'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T SERVICE 40% GLYCOL SOLUTION
P-2	MECH. ROOM	CHW TO AHU 1-4	65	37'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T SERVICE 40% GLYCOL SOLUTION
P-3	MECH. ROOM	RECIR. TO TANK	40	17'	1750	1/2	208/230	3	60	IN-LINE	B/G #60-13T SERVICE 40% GLYCOL SOLUTION
P-4	EXIST. MECH. ROOM	HW	73	31'	1750	1 1/2	208/230	3	60	IN-LINE	B/G #60-20T HOT WATER

NOTES:
1. Starters And Disconnects By E.C.

GRILLE, REGISTER AND DIFFUSER SCHEDULE										
ITEM	MANUFACTURER	MODEL NO.	QTY.	LOCATION	CFM EACH	AIR PATTERN	SIZE		FINISHES	REMARKS
							FRAME	NECK		
A	BARBER COLMAN	SFSV	8	126,127,128 144	245	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	
B	BARBER COLMAN	SFSV	2	142	275	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
C	BARBER COLMAN	SFSV	4	140, 141	240	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	
D	BARBER COLMAN	SFSV	2	139	270	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
E	BARBER COLMAN	SFSV	2	138	280	4-WAY	18"× 18"	10"Ø	#7 OFF-WHITE	
F	BARBER COLMAN	SFSV	2	136	250	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	
G	BARBER COLMAN	SFSV	2	135	235	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	
H	BARBER COLMAN	SFSV	3	134	100	4-WAY	12"× 12"	6"Ø	#7 OFF-WHITE	FIRE DAMPER SEE DETAIL A
I	BARBER COLMAN	SFSV	1	134	190	4-WAY	12"× 12"	8"Ø	#7 OFF-WHITE	FIRE DAMPER SEE DETAIL A
		SFSV	1	134						FIRE DAMPER

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Figure 7

15. The final recipient of a request for information (RFI) form is the _____.
    a. foreman
    b. architect or engineer
    c. superintendent
    d. general contractor

16. The two nationally recognized building codes are the *International Building Code®* and _____.
    a. MasterFormat™ 2004
    b. AIA Standard Format
    c. *NFPA 5000®*
    d. *CSI 13213*

17. In new CSI-formatted specifications, you would expect to find information on HVAC systems in Division _____.
    a. 7
    b. 10
    c. 15
    d. 23

18. In order to secure approval to furnish and install special equipment, a subcontractor must provide the contractor with a(n) _____.
    a. submittal
    b. cut list
    c. as-built
    d. takeoff

19. The purpose of an electronic wheel scaler is to _____.
    a. enlarge details shown on architectural drawings
    b. measure the diameter of pipe and other circular objects
    c. count the number of grilles and diffusers shown on drawings
    d. measure duct and piping runs shown on drawings

20. When performing a ductwork takeoff procedure, you should include the takeoff quantities for all the duct runs that have the same material, construction, acoustic lining, and insulation _____.
    a. in one column
    b. on a master sheet
    c. in an appendix
    d. on one takeoff sheet

Trade Terms Introduced in This Module

Change order: the documentation of a change management process, where changes in the Scope of Work that were originally agreed to by owner(s), contractor(s), and architects or engineer are recorded. Typically, the order is related to additions or deletions from the Scope of Work, and alters the completion date and/or the contract value.

Coordination drawings: Elevation, location, and other drawings produced for a project by the individual contractors for each trade to prevent a conflict between the trades regarding the installation of their materials and equipment. Development of these drawings evolves through a series of review and coordination meetings held by the various contractors.

Cut list: An information sheet that is derived from shop drawings. It is the shop guide for fabricating duct runs and fittings.

Detail drawing: A drawing of a feature that provides more elaborate information than is available on a plan.

Elevation view: A view that depicts a vertical side of a building, usually designated by the direction that side is facing; for example, right, left, east, or west elevation.

Floor plan: A building drawing indicating a plan view of a horizontal section at some distance above the floor, usually midway between the ceiling and the floor.

Longitudinal section: A section drawing in which the cut is made along the long dimension of a building.

Plan view: The overhead view of an object or structure.

Riser diagram: A one-line schematic depicting the layout, components, and connections of a piping system or electrical system.

Schedules: Tables that describe and specify the types and sizes of items required for the construction of a building.

Section drawing: A drawing that depicts a feature of a building as if there were a cut made through the middle of it.

Shop drawing: A drawing that indicates how to fabricate and install individual components of a construction project. A shop drawing may be drafted from the construction drawings of a project building or provided by the manufacturer.

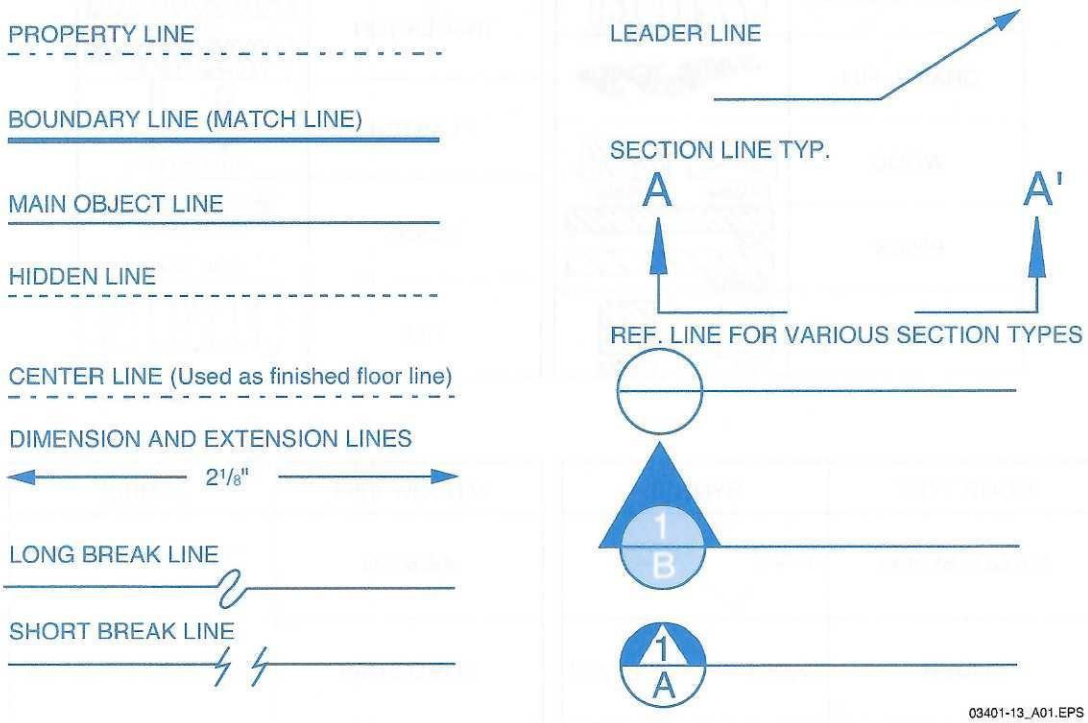
Site plan: A construction drawing that indicates the location of a building on a land site.

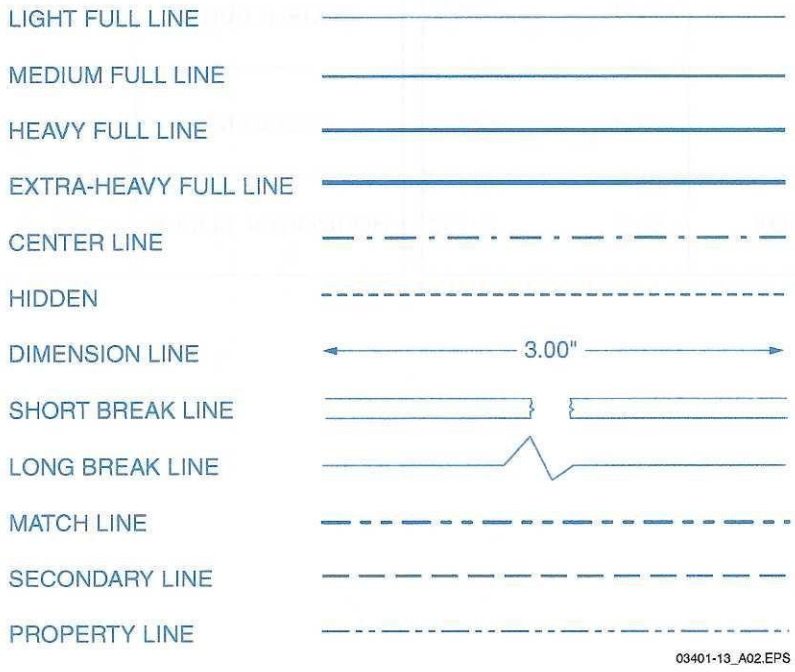
Takeoff: The process of surveying, measuring, itemizing, and counting all materials and equipment needed for a construction project, as indicated by the drawings.

Transverse section: A section drawing in which the cut is made through the short dimension of the building.

Appendix A

Drawing Symbols





MATERIAL	SYMBOL
EARTH	
CONCRETE	
CONCRETE BLOCK	
GRAVEL FILL	
WOOD	FRAMING FINISH
BRICK	FACE COMMON
STONE	CUT RUBBLE

MATERIAL	SYMBOL
STRUCTURAL STEEL BEAM	SPECIFY
SHEET METAL FLASHING	SHOW CONTOUR
INSULATION	LOOSE FILL or BATT BOARD
PLASTER	STUD LATH & PLASTER
GLASS	LARGE SCALE SMALL SCALE
TILE	

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DOOR TYPE	SYMBOL
SINGLE SWING	
SLIDER	
BIFOLD	
FRENCH	
ACCORDION	

WINDOW TYPE	SYMBOL
AWNING	
FIXED SASH	
DOUBLE HUNG	
CASEMENT	
HORIZONTAL SLIDER	

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ADD.	addition
AGGR	aggregate
L	angle
B	bathroom
BR	bedroom
BM	bench mark
BRKT	bracket
CLK	caulk
CHFR	chamfer
CND	conduit
CU FT	cubic foot, feet
DIM.	dimension
DR	drain
DWG	drawing
ELEV	elevation
ESC	escutcheon
FAB	fabricate
FLGE	flange
FLR	floor
GR	grade
GYP	gypsum
HDW	hardware
HTR	heater
" or IN.	inch, inches
I.D.	inside diameter
LH	left-hand
MEZZ	mezzanine
MO	masonry opening
MECH	mechanical
N	north
NO.	number
OC	on center
OPP	opposite
O.D.	outside diameter
PNL	panel
PSI	pounds per square inch
PWR	power
REINF	reinforce
RH	right-hand
RFA	released for approval
RFC	released for construction
RFD	released for design
RFI	released for information
SHTHG	sheathing
SQ	square
STR	structural
SYM	symbol
THERMO	thermostat
TYP	typical
UNFIN	unfinished
VEL	velocity
WV	wall vent
WHSE	warehouse
WH	weep hole
WDW	window
WP	working pressure

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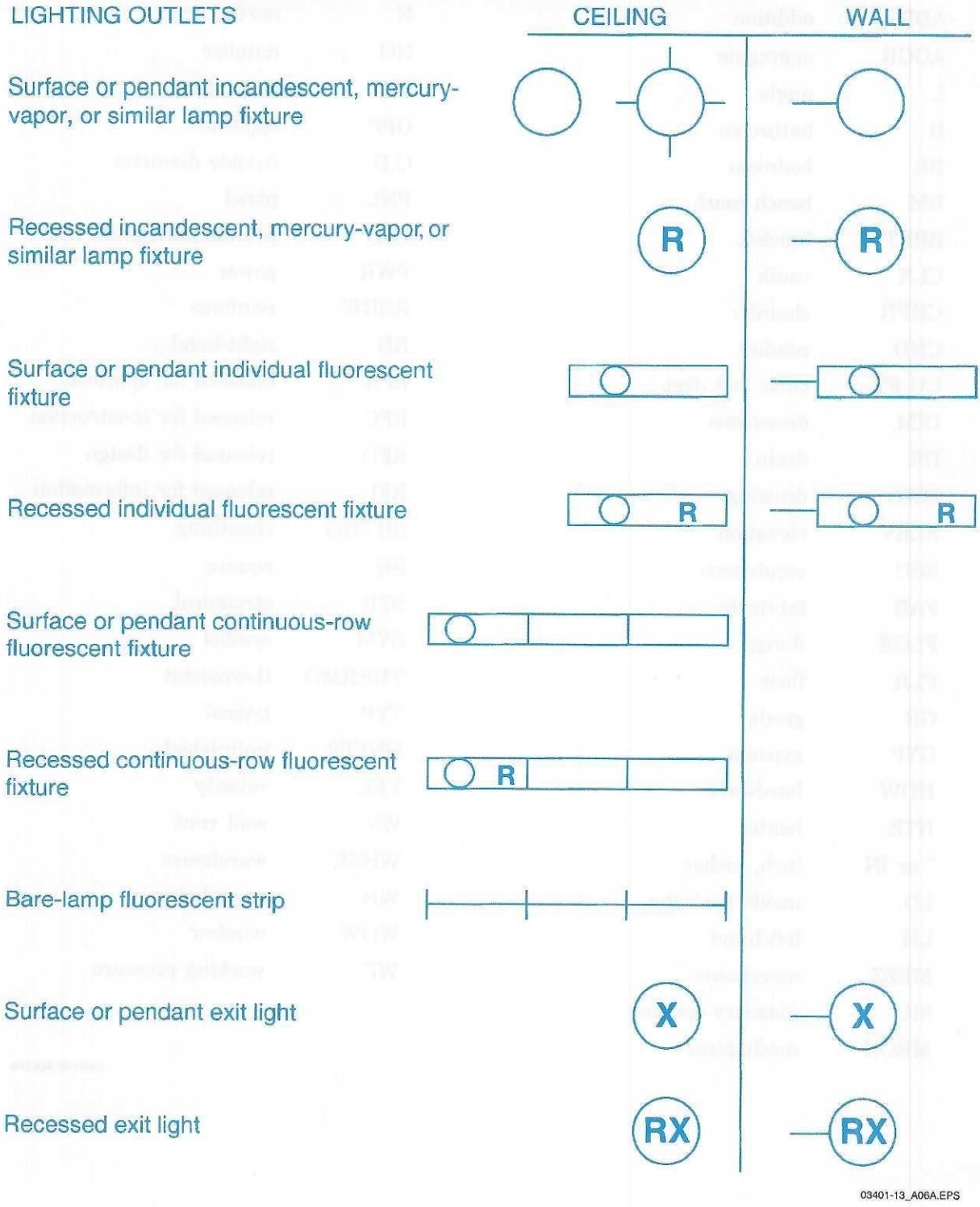
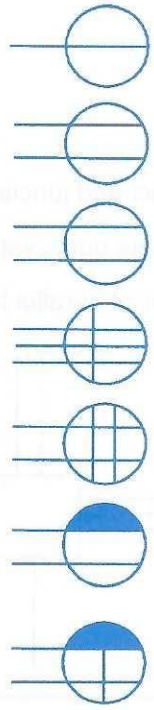
03401


LIGHTING OUTLETS
CEILING
WALL
Surface or pendant incandescent, mercury-vapor, or similar lamp fixture
Recessed incandescent, mercury-vapor, or similar lamp fixture
R
R
Surface or pendant individual fluorescent fixture
Recessed individual fluorescent fixture
R
R
Surface or pendant continuous-row fluorescent fixture
Recessed continuous-row fluorescent fixture
R
Bare-lamp fluorescent strip
Surface or pendant exit light
X
X
Recessed exit light
RX
RX
03401-13_A06A.EPS

	CEILING	WALL
Blanked outlet	B	B
Fan outlet	F	F
Drop cord	D	
Junction box	J	J
Outlet controlled by low-voltage switching when relay is installed in outlet box	L	L

RECEPTACLE OUTLETS	GROUNDED
Single receptacle outlet	
Duplex receptacle outlet	
Waterproof receptacle outlet	WP
Triplex receptacle outlet	
Fourplex (Quadruplex) receptacle outlet	
Duplex receptacle outlet, split wired	
Triplex receptacle outlet, split wired	



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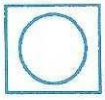
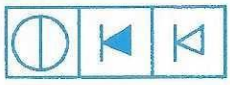
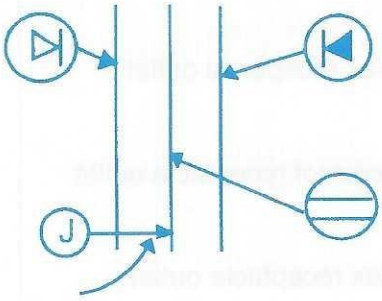
RECEPTACLE OUTLETS

	GROUNDED	UNGROUNDED
Floor duplex receptacle outlet		 UNG
Floor special-purpose outlet		 UNG
Floor telephone outlet, public		
Floor telephone outlet, private		

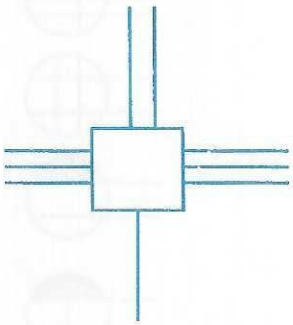
An example of using several floor outlet symbols to identify several gang floor outlets



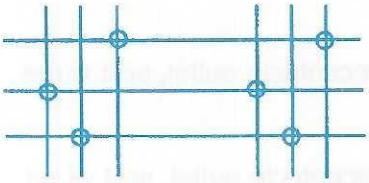
An example of the use of different symbols to show locations of different types of outlets or connections for underfloor duct or cellular floor systems



Underfloor duct and junction box for triple, double, or single duct system, as indicated by the number of parallel lines



Cellular floor header duct



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SWITCH OUTLETS

Single-pole switch	S
Double-pole switch	S_2
Three-way switch	S_3
Four-way switch	S_4
Key-operated switch	S_K
Switch and pilot lamp	S_P
Switch for low-voltage switching system	S_L
Master switch for low-voltage switching system	S_{LM}
Switch and single receptacle	S
Switch and double receptacle	S
Door switch	S_D
Time switch	S_T
Circuit breaker switch	S_{CB}
Momentary contact switch or pushbutton for other than signaling system	S_{MC}
Ceiling pull switch	(S)

SIGNALING SYSTEM OUTLETS FOR INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL OCCUPANCIES

Any type of nurse call system device	
Nurses' annunciator	1
Call station, single cord, pilot	2
Call station, double cord, microphone speaker	3
Corridor dome light, one lamp	4
Transformer	5
Any other item on same system (use numbers as required)	6
Any type of paging system device	
Keyboard	1
Flush annunciator	2
Two-face annunciator	3
Any other item on same system (use numbers as required)	4

03401-13_A06D.EPS

Any type of fire alarm system device, including smoke and sprinkler alarm devices

Control panel

Station

10-inch gong

Pre-signal chime

Any other item on same system (use numbers as required)

Any type of staff register system device

Phone operator's register

Entrance register, flush

Staff room register

Transformer

Any other item on same system (use numbers as required)

Any type of electric clock system device

Master clock

12-inch secondary, flush

12-inch double dial, wall mounted

Any other item on same system (use numbers as required)

Any type of public telephone system device

Switchboard

Desk phone

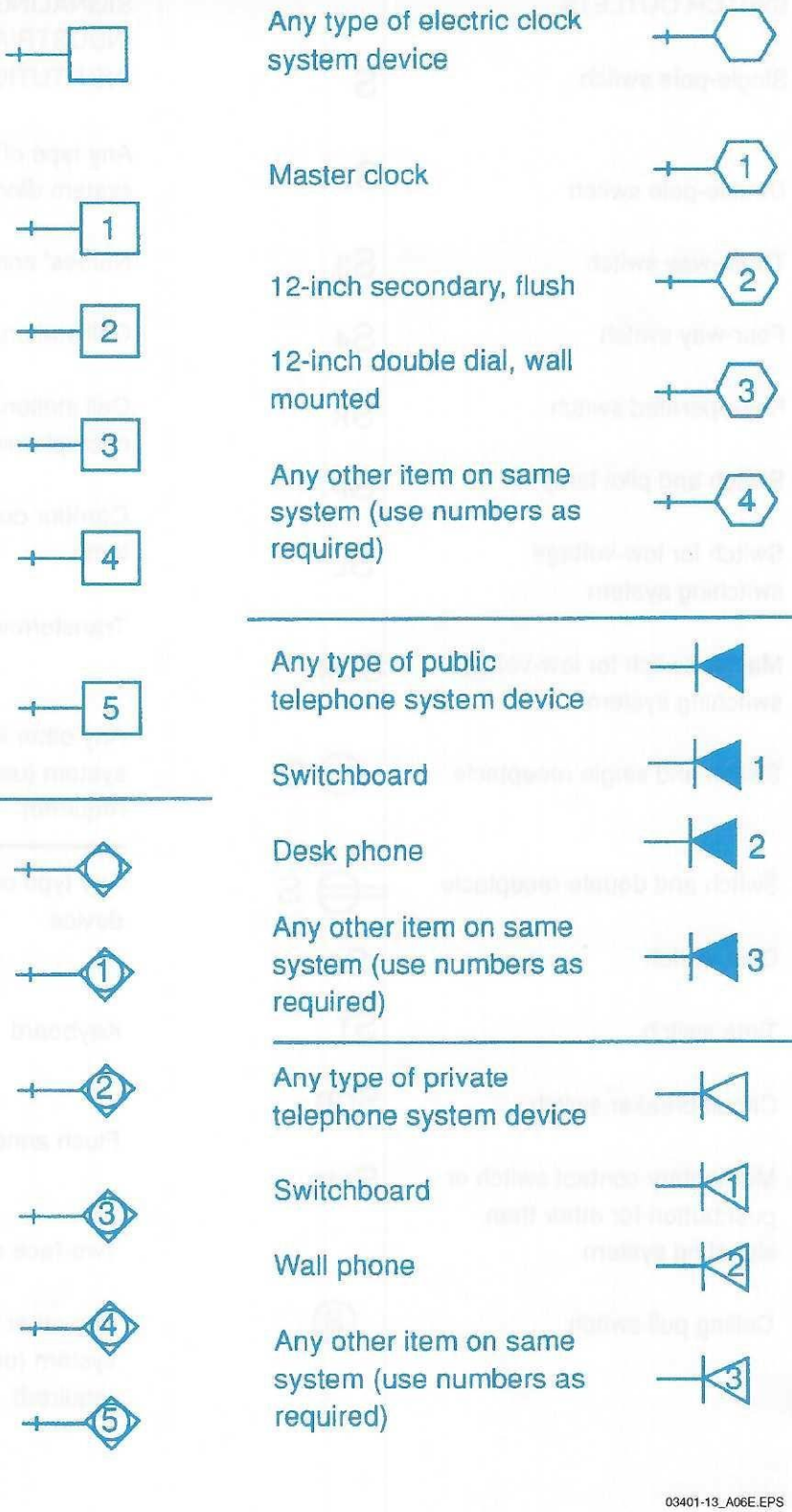
Any other item on same system (use numbers as required)

Any type of private telephone system device

Switchboard

Wall phone

Any other item on same system (use numbers as required)



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Any type of watchman system device

Central station

Key station

Any other item on the same system (use numbers as required)

Any type of sound system

Amplifier

Microphone

Interior speaker

Exterior speaker

Any other item on the same system (use numbers as required)

Any type of signal system device

Buzzer

Bell

Pushbutton

Annunciator

Any other item on system (use numbers as required)

RESIDENTIAL OCCUPANCIES

Pushbutton

Buzzer

Bell

Combination bell-buzzer

Chime

Annunciator

Electric door opener

Maid's signal

Interconnection box

Bell-ringing Transformer

Outside telephone

Interconnecting telephone

Radio outlet

Television outlet

03401-13_A06F.EPS

PANELBOARDS, SWITCHBOARDS, AND RELATED EQUIPMENT

Flush-mounted panel board and cabinet *

Surface-mounted panel board and cabinet*

Switchboard, power control center, unit substations (ANSI recommends drawing to scale)*

Flush-mounted terminal cabinet*

Surface-mounted terminal cabinet*

Pull box—identify in relation to wiring system section and size

Motor or other power controller*

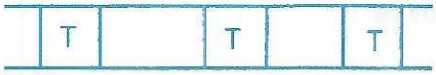
Externally operated disconnection switch*

Combination controller and disconnect means*

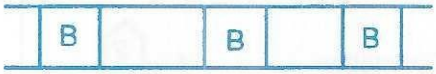
*Identify by notation or schedule

BUS DUCTS AND WIREWAYS

Trolley duct*



Busway (service, feeder, or plug-in)*



Cable trough, ladder, or channel*

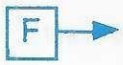
Wireway*

* Identify by notation or schedule

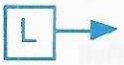
REMOTE CONTROL STATIONS FOR MOTORS OR OTHER

Pushbutton stations in general

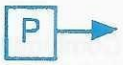
Float switch, mechanical



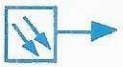
Limit switch, mechanical



Pneumatic switch, mechanical



Electric eye, beam source



Electric eye, relay

Thermostat

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ELECTRICAL DISTRIBUTION OR LIGHTING SYSTEMS, AERIAL

Pole*

Pole with street light*

Pole, with down guy and anchor*

Transformer*

Transformer, constant-current*

Switch, manual*

Circuit recloser, automatic* R

Line sectionalizer, automatic S

Circuit, series street lighting*

Down guy

Sidewalk guy

Service weather head*

SCHEMATIC CONVENTIONS

Transformer

Switch

Fuse

WASTE WATER

DRAIN OR WASTE – ABOVE GRADE	———
DRAIN OR WASTE – BELOW GRADE	— — —
VENT	- - - - - -
COMBINATION WASTE AND VENT	—CWV—
ACID WASTE	—AW—
ACID VENT	- - - AV - - -
INDIRECT DRAIN	—D—
STORM DRAIN	—SD—
SEWER – CAST IRON	—S-CI—
SEWER – CLAY TILE BELL & SPIGOT	—S-CT—
DRAIN – CLAY TILE BELL & SPIGOT	———

OTHER PIPING

GAS – LOW PRESSURE	—G—G—
GAS – MEDIUM PRESSURE	—MG—
GAS – HIGH PRESSURE	—HG—
COMPRESSED AIR	—A—
VACUUM	—V—
VACUUM CLEANING	—VC—
OXYGEN	—O—
LIQUID OXYGEN	—LOX—

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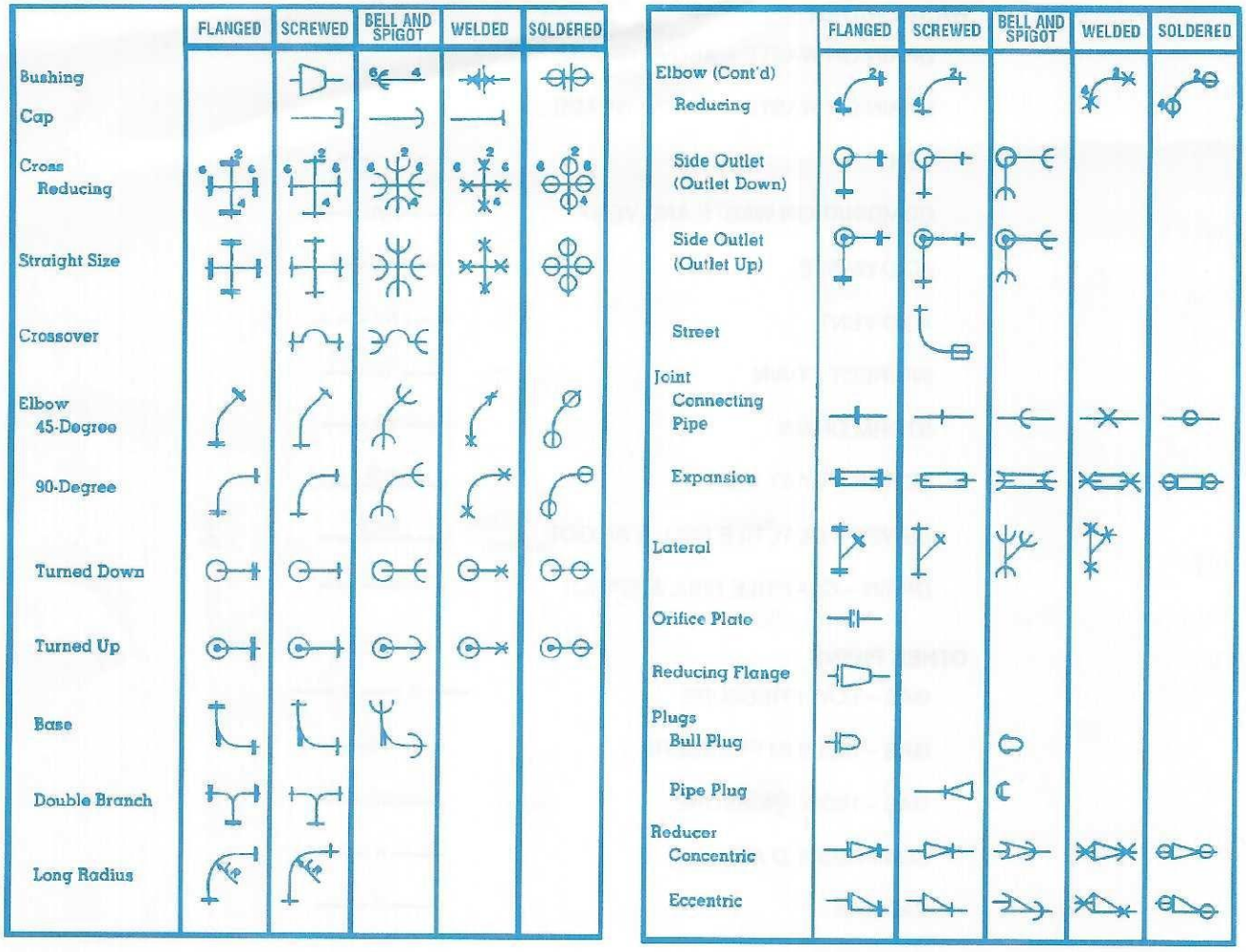

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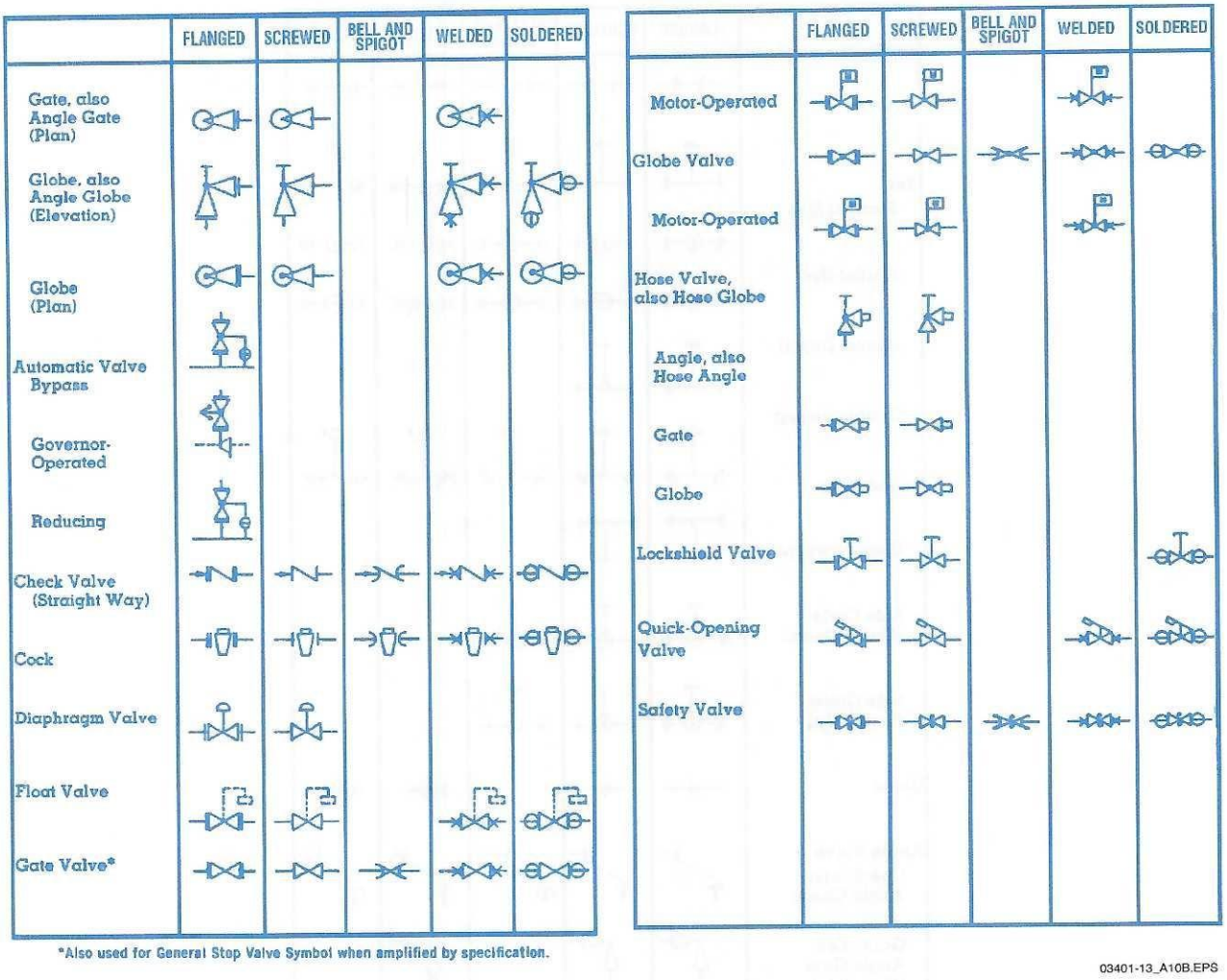
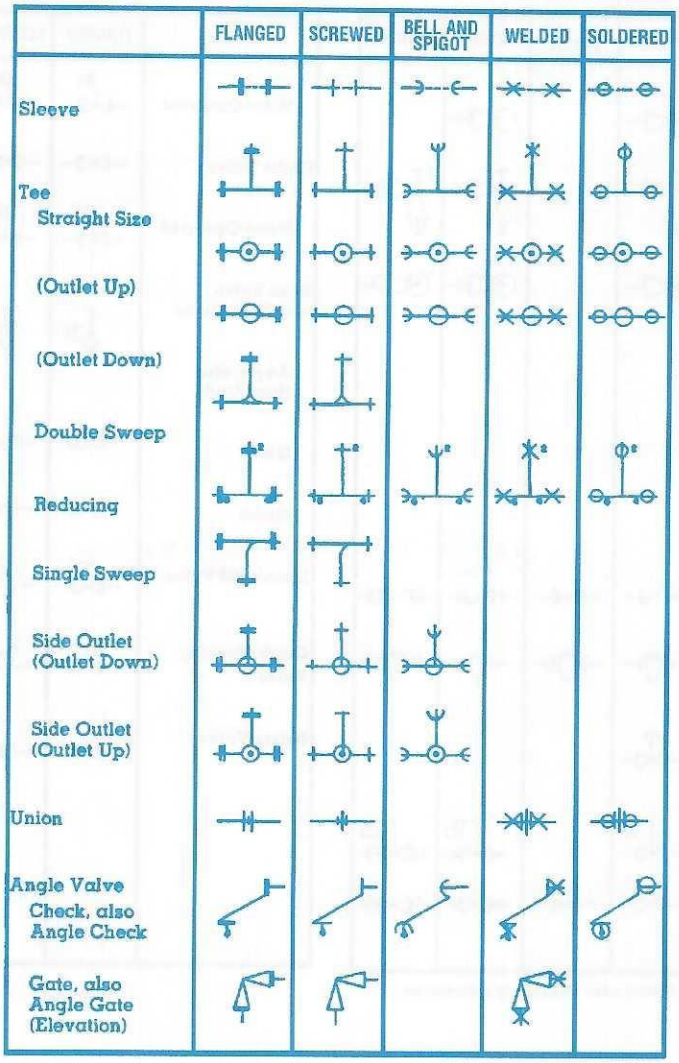


*Also used for General Stop Valve Symbol when amplified by specification.

03401-13_A10B.EPS



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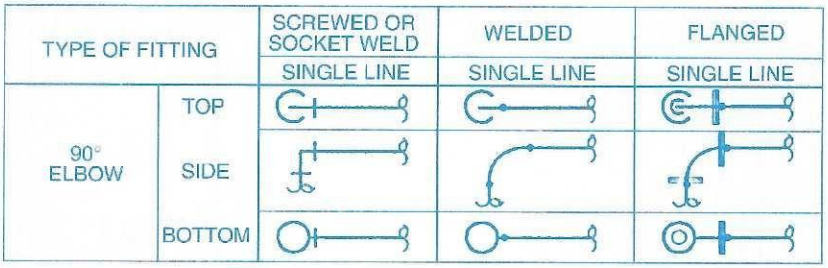
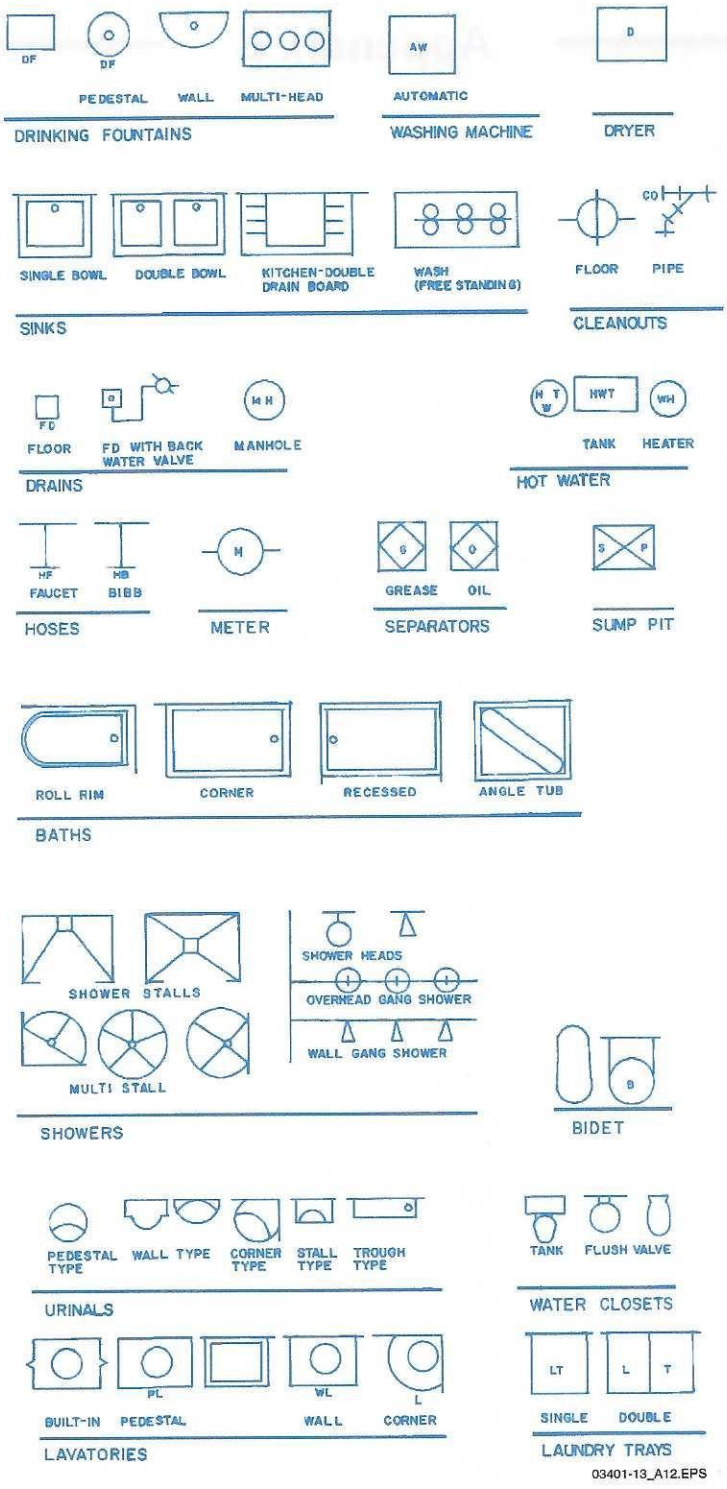


03401-13_A11.EPS


DF
DF
PEDESTAL
WALL
MULTI-HEAD
DRINKING FOUNTAINS
AW
AUTOMATIC
WASHING MACHINE
D
DRYER
SINGLE BOWL
DOUBLE BOWL
KITCHEN-DOUBLE DRAIN BOARD
WASH (FREE STANDING)
SINKS
CO
FLOOR
PIPE
CLEANOUTS
FD
FLOOR
FD WITH BACK WATER VALVE
MANHOLE
DRAINS
HWT
TANK
HEATER
HOT WATER
HF
HB
FAUCET
BIBB
HOSES
M
METER
G
O
GREASE
OIL
SEPARATORS
S
P
SUMP PIT
ROLL RIM
CORNER
RECESSED
ANGLE TUB
BATHS
SHOWER STALLS
MULTI STALL
SHOWER HEADS
OVERHEAD GANG SHOWER
WALL GANG SHOWER
SHOWERS
B
BIDET
PEDESTAL TYPE
WALL TYPE
CORNER TYPE
STALL TYPE
TROUGH TYPE
URINALS
TANK
FLUSH VALVE
WATER CLOSETS
PL
WL
L
BUILT-IN
PEDESTAL
WALL
CORNER
LAVATORIES
LT
L
T
SINGLE
DOUBLE
LAUNDRY TRAYS
03401-13_A12.EPS

Appendix B

SPECIFICATIONS

SECTION 23 54 00
GAS FIRED FURNACES

PART 1 - GENERAL

SCOPE
This section includes specifications for gas fired furnaces. Included are the following topics:

PART 1 - GENERAL
- Scope
- Related Work
- Reference
- Reference Standards
- Quality Assurance
- Energy Efficiency
- Submittals
- Operation and Maintenance Data
- Warranty

PART 2 - PRODUCTS
- Furnaces

PART 3 - EXECUTION
- Installation
- Furnaces
- Construction Verification Items
- Functional Performance Testing
- Agency Training

RELATED WORK
Section 01 91 01 or 01 91 02 – Commissioning Process
Section 23 08 00 – Commissioning of HVAC
Section 23 11 00 - Facility Fuel Piping
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 51 00 - Breechings, Chimneys, and Stacks

REFERENCE
Applicable provisions of Division 1 govern work under this section.

REFERENCE STANDARDS

AGA	American Gas Association
ANSI Z21.64	Direct Vent Central Furnaces
GAMA	Gas Appliance Manufacturers Association
NEC	National Electrical Code

QUALITY ASSURANCE
Refer to division 1, General Conditions, Equals and Substitutions.

ENERGY EFFICIENCY
Provide gas furnaces that bear the ENERGY STAR label and meet the ENERGY STAR specifications for energy efficiency.

SUBMITTALS
Refer to division 1, General Conditions, Submittals.

Include specific manufacturer and model numbers, equipment identification corresponding to project drawings and schedules, dimensions, capacities, materials of construction, ratings, weights, power requirements and wiring diagrams, filter information and information for all accessories.

OPERATION AND MAINTENANCE DATA
All operations and maintenance data shall comply with the submission and content requirements specified under section GENERAL REQUIREMENTS.

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WARRANTY

Furnace primary and secondary heat exchangers warranted for 20 years under normal use and maintenance. Remainder of furnace components warranted for 1 year from date of start up.

PART 2 - PRODUCTS

FURNACES

Approved Manufacturers: Bryant, Carrier, Lennox, Trane or York.

Direct-vent, sealed-combustion, condensing-type AGA certified warm-air furnace for use with natural gas. Minimum annual fuel utilization efficiency (A.F.U.E.) of 91 is required. All ratings are to be certified by GAMA. All wiring shall comply with the National Electrical Code.

22 gauge steel casing with baked enamel finish or prepainted galvanized steel. Insulate casing back and side panels with foil faced fiberglass insulation.

Construct primary heat exchanger of aluminized steel. Construct secondary heat exchanger of stainless steel with aluminum fins or of polypropylene laminated steel. Aluminized steel multi-port in-shot burner with hot surface or electronic spark ignition, approved for vertical or sidewall venting.

AGA listed gas controls including manual main shut-off valve, double automatic gas valves for redundancy and gas pressure regulator.

Centrifugal type blower fan statically and dynamically balanced with multiple speed, direct drive or belt drive fan motor. Provide low energy induced draft blower for heat exchanger prepurge and combustion gas venting.

Provide unit(s) with 2" thick 30% efficient disposable type panel air filter and filter holding rack with a maximum filter face velocity of 225 fpm.

Provide solid state integral control unit with all necessary controls and relays including but not limited to:

- -Pressure switch for airflow of flue products through furnace and out vent system
- -Rollout switch with manual reset to prevent overtemperature in burner area
- -Electronic flame sensor
- -Blower access safety interlock
- -Timed blower start after main burners ignite
- -Factory installed 24 v transformer for controls and thermostat
- -LED's to indicate status and to aid in troubleshooting

Provide unit with matching cased "A" configuration cooling coil for upflow units, "V" configuration cooling coil for downflow units, and vertical flat face configuration cooling coil for horizontal units.

Minimum 1/2" OD seamless copper tubing mechanically bonded to heavy ripple edged aluminum fins with thermal expansion valve, holding charge and copper tube stubs for field piping.

Non-corrosive stainless steel or polymer drain pan with 3/4" NPT drain connection.

20 gauge steel Coil casing with baked enamel finish and fiberglass insulation.

This Contractor shall provide all temperature control and interlocking necessary to perform the specified control sequence. All wiring is to be in conduit in accordance with Division 26 00 00 - Electrical. All relays, transformers, and controls are to be in enclosures.

Provide a 7-day programmable thermostat with 2 occupied periods per day, automatic changeover, separate heating and cooling set points for both occupied and unoccupied modes. Provide auxiliary controls on sub-base to open minimum outside air damper during occupied mode. Equal to Honeywell model T7300 with Q7300 sub-base.

Provide lockable thermostat guards in public spaces.

During occupied mode run the supply fan continuously, open the outside air damper and cycle the cooling or heating as required to maintain occupied space temperature cooling or heating set point. During

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unoccupied mode close the outside air damper and cycle the supply fan and cooling or heating as required to maintain unoccupied cooling or heating space temperature set point.

PART 3 - EXECUTION

INSTALLATION

Install units as shown on plans, as detailed and according to the manufacturer's installation instructions.

Pipe vents from gas regulator to outside (where regulators are provided).

Install remote panels and thermostats where indicated on the drawings. Provide all wiring between remote panels/thermostats and the gas fired item.

FURNACES

Install on concrete housekeeping pad, steel stand or suspend unit from structure as indicated on the drawings. Pipe condensate to floor drain.

Provide schedule 40 PVC, ASTM D1785 combustion air and vent piping and fittings with solvent welded joints as indicated on the drawings. Terminate as recommended by the furnace manufacturer.

CONSTRUCTION VERIFICATION

Contractor is responsible for utilizing the construction verification checklists supplied under specification Section 23 08 00 in accordance with the procedures defined for construction verification in Section 01 91 01 or 01 91 02.

FUNCTIONAL PERFORMANCE TESTING

Contractor is responsible for utilizing the functional performance test forms supplied under specification Section 23 08 00 in accordance with the procedures defined for functional performance testing in Section 01 91 01 or 01 91 02.

AGENCY TRAINING

All training provided for agency shall comply with the format, general content requirements and submission guidelines specified under Section 01 91 01 or 01 91 02.

END OF SECTION

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Additional Resources

This module presents thorough resources for task training. The following resource material is suggested for further study.

Blueprint Reading for Construction, 2003. Second Edition. James A. S. Fatzinger, Upper Saddle River, NJ: Pearson/Prentice Hall.

Construction Specifications Writing: Principles and Procedures, 2010. Sixth Edition. Mark Kalin, Robert S. Weygant, Harold J. Rosen, and John R. Regener. Hoboken, NJ: John Wiley & Sons, Inc.

Reading Architectural Work Drawings, 2003. Sixth Edition. Edward J. Muller and Phillip A. Grau III. Upper Saddle River, NJ: Prentice Hall.

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Kogok Corporation, Figure 18

Courtesy of Hypertherm Inc., Figure 20

Carnes Company, Figure 23

Courtesy of Calculated Industries, SA04, SA05

Section Review Question Answers

Answer	Section Reference	Objective
Section One		
1.a	1.1.0	1a
2.c	1.2.0	1b
3.d	1.3.2	1c
4.d	1.4.1	1d
5.a	1.5.1	1e
6.b	1.6.0	1f
7.d	1.7.0	1g
8.c	1.8.0	1h
9.b	1.9.0	1i
Section Two		
1.a	2.1.1	2a
2.b	2.2.0	2b
Section Three		
1.b	3.1.0	3a
2.c	3.2.0	3b

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