PLUMBING AND PIPING SYSTEMS

INSPECTION NOTES

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UP TO CODE

Plumbing and Piping Systems Inspection Notes

INSPECTING COMMERCIAL, INDUSTRIAL, AND RESIDENTIAL PROPERTIES

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0-07-146539-1

The material in this eBook also appears in the print version of this title: 0-07-144888-8

DOI: 10 1036/0071465391

The IBC Building Code's Purpose

"101.3 Intent. The purpose of this code is to provide minimum requirements to safeguard the public health, safety and general welfare. . . ."

INTERNATIONAL CODE COUNCIL

CONTENTS

CHAPTER 1
INTRODUCTION

Up to Code Inspectors Guides comprise a series of manuals covering different CSI construction procedures and standards for commercial and industrial projects. Although based on the IBC 2003 and IRC 2003 codes, these guides are not intended to replace these codes or any of the other model codes and/or specifications in the contract documents. The goal is for the Inspector and/or project site managers to use these guides as a basis for establishing his or her inspection guidelines, and for providing the client with a well-built project meeting the specifications. The convenient sizing of these guides allows the Inspector to carry them around in a pocket, making code and standards information readily accessible. Furthermore, our intent is for this reference tool to be instrumental in the construction of better buildings and to be a valuable training guide for those just entering the construction field. These guides are valuable tools for architects, engineers, project managers, tradespeople, and contractors, as well as inspectors.

REFERENCED MATERIALS

- International Building Code 2003
- International Residential Code 2003
- National Electrical Code (NEC) 2002
- International Fuel Gas Code 2003
- International Fire Codes 2003
- International Energy Conservation Code 2000
- International Mechanical Code 2003
- ACI 318-02/318R-02 Building Code Requirements for Structural Concrete and Commentary
- ACI 530/530.1-02/530R/530.1R-02 Building Code Requirements and Commentary for Masonry Structures and Specification for Masonry Structures and Related Commentaries
- ACI 301-99 Specifications for Structural Concrete for Buildings
- ACI 306.1-90 Standard Specification for Cold Weather Concrete
- ACI 305R-99 Hot Weather Concreting

- ACI 302.1R-96 Guide for Concrete Floor and Slab Construction
- ACI 117-90/177R-90 Standard Tolerances for Concrete Construction and Materials (AC1117-90) and Commentary (ACI117R-90)
- ACI SP-2-99 Manual of Concrete Inspection
- ACI 311.4R-00 Guide for Concrete Inspection
- American Concrete Institute (ACI) 347R "Formwork for Concrete"
- Americans with Disability Act of 1990 (ADA)
- American Forest Association
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- American Wood Preservers Association (AWPA)
- APA—The Engineered Wood Association (EWA)

One or more International Codes currently enforced statewide

One or more International Codes enforced within state at local level

Adopted statewide with future enforcement date

Figure 1.1 ICC CODE ADOPTIONS

- Factory Mutual (FM)
- Truss Plate Institute (TPI) HIB-91
- OSHA Safety and Health (29 CFR 1926), 2003
- Portland Cement Association (PCA) Design and Control of Concrete Mixtures
- American Society of Concrete Contractors (ASCC) "Contractor's Guide to Quality Concrete Construction"

THE INSPECTOR'S ROLE

As an Owner's Representative and/or the Project Resident Inspector, you should be thoroughly familiar with all the contract documents, including the plans with all changes, specifications, and contracts submittals such as shop drawings. Plans and specifications should include all revisions, changes, and amendments. In addition, you should be thoroughly familiar with the project's reporting requirements as well as the specific duties and responsibilities (including the limits) associated with the project. Procedures and responsibilities will differ from project to project. It is crucial that the Inspector have a clear understanding of the project's responsibilities, as well as all reporting required prior to the start of the project.

Responsibilities of the Inspector

Inspectors have different responsibilities and authorities, depending on the organizational setup, and size and scope of the project. Each Inspector should be clear on the answers to each of the following questions:

- ❑ Do I understand the limits of my responsibility?
- ❑ Do I have the technical knowledge required for this project? Can any gaps in my knowledge be effectively covered with the help of other inspection staff and or consultants?
- ❑ Do I fully understand all reporting procedures?
- ❑ Do I fully understand where I fit in the organizational chart and to whom I report?
- ❑ Am I given sufficient authority to carry out my duties and responsibilities?
- ❑ Make sure you know the extent of your authority. At a minimum, your responsibility is to inspect all work and ensure that it's accomplished in accordance with the contract plans and specifications. Be sure you have the authority you need to meet that responsibility.
- ❑ Check with your supervisor with respect to your authority to stop subcontractor operations for safety violations, construction deficiencies, or other potential problems.

Quality Control Issues in the Inspector's Role

- Subcontractors may be required to provide additional inspectors in the interest of quality control either part time or full time, depending on the requirements of the project. This is especially true for government projects. As

the project's primary Inspector, it is your responsibility to oversee any additional inspectors, and to determine their qualifications and ability to perform their duties.

- The main role of the Inspector is to ensure the owner that the quality requirements of the contract are satisfied.
- At times, projects will require a Subcontractor Quality Control Program, which is made up of inspectors responsible for the quality of each subcontracted aspect of the job. For example, the masonry subcontractor would have a masonry inspector, the electrician would have an electrical inspector, etc. Although the responsibility for overseeing a Subcontractor Quality Control Program is usually the contractor's, you should develop a close working relationship with each Inspector. For some projects, they may report directly to you.
- Effective project inspections require a serious and concentrated effort on the part of all the Inspectors, as well as all site management personnel.

CONTRACT REQUIREMENTS

Contract requirements provide the tools for the accomplishment of the goals. Before the start of

construction, the Project Manager shall conduct a meeting of all contractors and discuss their individual quality control plans and procedures. Construction should not start until the meeting has taken place, and, at minimum, until the Project Quality Control plan has been submitted and accepted. Project staffing should be sufficient to obtain the quality of construction designed in the plans and specifications.

The following sections describe the methods for meeting contract requirements.

Preconstruction Meetings

These meetings may be held before each stage of construction. For example, at the start of foundations, masonry work, slab on grade, plumbing grounds, etc., ensure the following:

- ❏ The requirements are understood by all managers and workers.
- ❏ The documentation is complete.
- ❏ The materials are on hand.
- ❏ The people who are to perform the work understand what will be considered satisfactory workmanship.

Both the contract specifications and technical standards referenced in the contract specifications must be in the Job Site Trailer library and

available to the inspectors. For instance, the truss placement specifications depend entirely on the Truss Plate Institute HIB-91 (TPI) Specifications for all requirements. If the Inspector doesn't have the TPI specifications, he cannot know or enforce these provisions.

Initial Inspections

These inspections must be conducted in a timely manner at the beginning of a definable feature of work. A check of the preliminary work will determine whether or not the subcontractor—through his Quality Control Manager and the craftsmen involved—thoroughly understands and is capable of accomplishing the work as specified. Check for proper implementation of safety procedures according to the approved Safety Plan at this time.

Follow-up Inspections

Follow-up inspections are conducted daily when work is in progress. This ensures that the controls established in the earlier phases of inspection continue to conform to the contract requirements.

In all projects there is work that is eventually covered and cannot be inspected after the fact.

This includes concrete, where the size, number, and location of reinforcing steel cannot be readily determined after the concrete is placed. Underground utilities cannot be inspected after covering. Work of this nature must be closely controlled and monitored during construction. If the contractor was notified to not cover until you have completed your inspection but does so anyway, then you can direct him to uncover the work at his expense!

PLANS AND SPECIFICATIONS

Review of Plans and Specifications

Make a thorough review of plans and specifications before the bidding period.

- ❏ Watch for omissions.
- ❏ Watch for discrepancies between plans and specifications.
- ❏ Check plans and specifications against requirements that have been problematic on similar jobs.
- ❏ Compare elevations, grades, and details shown on plans as existing against those at the actual site.
- ❏ Report all errors, omissions, discrepancies, and deficiencies to the Project Manager.

Marked and Posted Plans and Specifications

Always keep a posted and marked up set of plans and specifications convenient for ready reference. Keep them up to date!

- ❑ Make sure that the Subcontractor has this same information.
- ❑ Anticipate work operations by reviewing the plans and specifications for each operation before it begins.
- ❑ Discuss contract requirements with the Subcontractor before each construction phase begins.
- ❑ Highlight and/or make notes of those provisions which need special attention, such as:
  (a) Unusual requirements, such as additional concrete test.
  (b) Those requirements overlooked by other contractors.
  (c) Repetitive deficiencies.
  (d) Conflicting specifications and drawings.
  (e) Code violations.
  (f) Use the checklists in the Design Quality Control chapter to help find significant items in the plans and specifications.

REQUIRED GEOGRAPHIC DESIGN CRITERIA	
Ground snow load	
Roof snow load	
Wind speed	
Seismic zone	
Weathering zone	
Frost line	
Termite zone	
Decay zone	
Flood zone	
Winter design temperature	
Climate zones (energy code)	
Heating degree days	
Cooling degree days	
Radon zone	
Exposure profile (wind)	
January average temperature	

Shop Drawings

- ❑ Review the prepared subcontractor submittal register, plans, and specifications. Check submittal register for inclusion of all shop drawings required, including layouts of equipment, equipment rooms, etc. The Inspector must have copies of all shop drawings!

- ❏ The Subcontractor is required to enter his or her data onto the submittal register and submit it to the Project Control Administrator or others tasked with this responsibility. Compare this submittal with your check list.
- ❏ The Project Manager is required to periodically review and update the submittal register. The Inspector should monitor each change.
- ❏ Check the submittal register to prevent untimely and omitted submittals so as to avoid delay of construction. Check specifications for required turnaround time requirements.
- ❏ Compare the shop drawings to the contract requirements and report apparent differences to your supervisor.
- ❏ Make sure each detail on the shop drawing is clearly presented.
- ❏ The Subcontractor must make notes on his submittal of items that deviate from contract requirements.
- ❏ Check material being installed against the approved shop drawing. (If the Subcontractor installs unapproved material, inform him or her in writing that the material, if not subsequently approved, will be removed and replaced at his or her expense.)

Inspection Report

(a) Prepare a complete and accurate daily inspection report. Modify the form to reflect all requirements noted in the specifications and contract documents. Include the following:

- ❑ **Conditions** weather, moisture, soil conditions, etc. Note when and how an adverse site condition hampered or shut down a particular operation.
- ❑ **Activities** work phases, including locations and descriptions of each activity and the inspection.
- ❑ **Controversial issues** disputes, questionable items, etc. (Also, note if they were settled and, if so, how they were settled.)
- ❑ **Deficiencies and violations** description, location, and corrective action.
- ❑ **Instructions** given and received; identify recipient and source.
- ❑ **Progress information** report all delays, anticipated and actual, and action taken or contemplated.
- ❑ **Equipment** report arrival and departure of each major item of equipment by manufacturer, model, serial number, and capacity; report equipment in use and idle equipment.

- ❑ **Reports** make sure reports are identified, dated, and signed.
- ❑ **Safety** check the daily report each day for accuracy and to ensure that instructions received are noted.

PRECONSTRUCTION MEETING

Attendees

Both the Inspector and the Project Manager should attend this conference as well as all contractors' representatives associated with the project.

Documentation of Meeting

Minutes of the meeting should be available to each quality assurance/quality control representative. The subject of the proposed quality control plan should be well documented.

EQUIPMENT PROPOSAL/EVALUATION

The following issues must be resolved and/or finalized before start of construction.

- ❑ Does equipment proposed by the Subcontractor have proper approval for use?
- ❑ Certain equipment requires a safety test or check before initial operation at the site.

- ❑ Some equipment requires a permit or license before use.
- ❑ Have daily/weekly equipment rates been approved?
- ❑ Has equipment been recently inspected?
- ❑ Have all oils, lubricants, and their containers been properly discarded per EPA and OSHA requirements?

CLAIMS AND DISPUTES

Be sure the following conditions are met:

- ❑ Always be alert to possible claims or matters of possible dispute.
- ❑ When you discover that a claim or dispute is imminent, notify your supervisor and record all facts in your (Inspector) daily reports.
- ❑ Make sure that adequate and accurate records of facts, materials, labor, and equipment associated with the claim or dispute are on file.
- ❑ Situation photographs should be taken to supplement the record.
- ❑ Differing site conditions may be cause for a claim. Subcontractors must notify PM in writing before disturbing conditions.

PROGRESS SCHEDULES

Steps to ensure efficient evaluation are as follows:

- Assist the Subcontractor as he or she prepares initial and revised progress schedules.
- Be certain the Contractor submits timely updates.
- Be familiar with the approved progress schedule, carefully watching for any slippage in progress.
- Anticipate slowdowns and delays affecting progress.
- Promptly report all delays to the Project Manager and record them in the daily reports. Perform manpower analysis as needed.
- When construction falls behind schedule, carefully examine the construction operations for ways to improve efficiency and report your findings to the Superintendent and Project Manager.
- Be very careful not to presume direction of the Subcontractor's operation (the PM/Superintendent is responsible to direct the Contractor on how to improve his progress).
- Monitor required contract milestones and the final completion date.

LABOR ENFORCEMENT

The following precautions must be taken to avoid labor liabilities:

- Keep informed of the labor requirements of the contracts.
- Avoid taking part in any labor disputes. Inform the Project Manager of any labor disputes.
- Check that required posters and minimum wage rates are kept in a conspicuous place.
- Make spot checks with Sub-subcontractors' employees to verify that Davis-Bacon wage rates are being paid for the work classification being performed (if required).

STORAGE OF MATERIALS

- ❑ Check that adequate space is available for the Subcontractors' operations and storage areas (before the materials are scheduled for delivery).
- ❑ Check that approval has been obtained for temporary sheds, buildings, etc. that the Subcontractor proposes to install.
- ❑ See that material and equipment are properly stored and protected.
- ❑ Check that safety requirements, especially in the storage of flammable or explosive materials, are adhered to.

- ❑ Check that temporary structures are secured against wind damage.
- ❑ Check that the necessary heating and ventilating are provided.

SUB-SUBCONTRACTOR'S PAYMENT ESTIMATES (IF REQUIRED)

- ❑ Check work evaluation and payment specifications for each item of work to be accomplished.
- ❑ Review the schedules of values and methods of measurement for payment.
- ❑ Assist the Project Manager in preparing pay estimates.
  - (a) Record timely measurements of work completed and accomplished each pay period.
  - (b) Keep orderly, neat, and accurate records of measurements.
- ❑ Check material on hand for which payment is being made for:
  - (a) Fair market value of materials.
  - (b) Conformance with contract requirements (see submittal).
  - (c) Proper storage and protection.
  - (d) Reduction in quantity by material was placed in the work.

- ❑ Monitor all increases or decreases in the quantity of work shown on the unit price schedules.
  (a) Make as accurate an estimate as possible of variations in quantities.
  (b) Report these variations in quantities promptly to the Construction and/or Project Manager.
  (c) Keep all estimates for future record.

RIGHTS-OF-WAY

Check that all rights-of-way are obtained before beginning construction or entering the property.

(a) Require written evidence if Subcontractor-obtained.
(b) Know the limits of rights-of-way and locations of benchmarks that may be used to determine location and elevations.
(c) Post signs for workers and drivers to mark limits of operational area.

PHOTOGRAPHS

Property Evaluation and Overview

Photographs will provide information that can evaluate potential hazardous conditions as well as an overview of work progress. Check them for the following indications:

- ❑ Views of major construction projected during various stages of progress.
- ❑ Materials or construction related to changed conditions, claims, or potential claims.
- ❑ Work in place for which removal has been ordered because of noncompliance with plans and specifications.
- ❑ Photos of technical interest.
- ❑ Bad and good safety practices by the contractors.
- ❑ New methods of construction.
- ❑ Property or material damages.
- ❑ Manufacturers' labels and installation instructions.
- ❑ Emergency conditions and safety violations.
- ❑ Accident scenes.
- ❑ Defective work
  - (1) Check that each picture taken is completely described, identified, and dated.
  - (2) When possible, use a tape measure or other measurement device in pictures to show actual sizes and distances.

RECORD DRAWINGS

(a) The Record Drawings should be reviewed monthly by the Project Manager to ensure their accuracy.

(b) The Site Superintendent or Project Manager must ensure that as soon as a change or addition is made in construction it is noted on the Record Drawing. In some cases, however, this becomes the Inspector's responsibility. Good inspection practice dictates that the Inspector keep good record drawings whether or not they are the set to be turned over to the client or owner.

(c) The following items must be considered in the changes for Record Drawings:

- Size, type, and location of existing and new utility lines.
- Layout and schematic drawings of electrical circuits and piping; include sleeve drawings and diagrams.
- Dimensions and details transferred from shop drawings.
- Final survey records of cross sections, borrow pits, and layout of all earthwork.
- Actual locations of anchors, construction and control joints, etc. in concrete, where they are different from those shown on Contract drawings.
- Changes in equipment location and architectural features.
- Any and all project Change Orders and Field Directives.

PROJECT TURNOVER

The Inspector may have the responsibility of providing the client or owner the official turnover documents (OEM manuals). The following records and materials will be needed.

- ❑ Record of property name, make, and model number of each piece of equipment.
- ❑ All equipment test reports.
- ❑ Approved shop drawings.
- ❑ Operating and maintenance instructions.
- ❑ Spare parts and tools.
- ❑ Keys.
- ❑ Guarantees with required contract and expiration date.
- ❑ Record (As-Built) Drawings.

Check meeting minutes and contract documents for any additional requirements.

QUALITY CONTROL

Remember that the Inspector's responsibilities begin at the inception of construction and end only with the final acceptance by the owner. The Inspector's primary objective is to verify what has been accomplished as well as possible oversights.

SAFETY

(a) The overall Project Safety Programs as well as each individual contractor's safety program must be approved and enforced every day. This enforcement is usually not the duty of the Inspector, unless specified in the contract. Large projects will have a full-time Safety Manager.
(b) Fully assess all work or operations for safety compliance before proceeding with inspecting for the technical compliance.
(c) Be familiar with each contractor's accident prevention programs. These plans should be discussed and finalized before any construction begins.
(d) Plan to attend a different contractor's weekly safety meeting. Stand ready to evaluate and advise.
(e) Applicable Occupational Safety and Health Act (OSHA).

INSPECTION FILES

The following list suggests those files that the Inspector will require for a project. Depending on the size and complexity of the project, the Inspector may need to add additional files, as

appropriate, to ensure adequate documentation for the project.

(a) **GENERAL**

- ❑ Project Contract
- ❑ Contractors Contract
- ❑ Clarifications
- ❑ Request for Change Orders
- ❑ Approved Change Orders
- ❑ Field Directives
- ❑ Claims
- ❑ Schedule of Values
- ❑ Request for Payments
- ❑ Owner furnished Labor/Materials
- ❑ Selections
- ❑ Shop Drawings

(b) **CORRESPONDENCE**

- ❑ Architect/Engineer
- ❑ Client
- ❑ Contractor
- ❑ Testing labs
- ❑ Consultants
- ❑ Others/Misc.

(c) **GOVERNMENT AGENCIES**

- ❑ Permits
- ❑ Fire Marshal
- ❑ Certified Payrolls
- ❑ Special

(d) **FIELD**
- ❑ Transmittals
- ❑ Sketches
- ❑ Request for Information (RFI)
- ❑ Meeting Minutes
- ❑ Schedules
- ❑ Issues Log
- ❑ Daily/Weekly Reports
- ❑ Safety Plans/Reports

(e) **TECHNICAL INFORMATION**
- ❑ One file per CSI Division

(f) **CLOSE-OUTS**
- ❑ MSDA Sheets
- ❑ Equipment Instructions
- ❑ Certificate of Occupancy
- ❑ Code Inspection Reports
- ❑ Warrantees/Guarantees
- ❑ Record Drawings

Recommended Equipment

- ❑ 12-ft steel tape measure
- ❑ 100-ft cloth/plastic tape measure
- ❑ 4-ft level
- ❑ 8-ft level
- ❑ Scales (architect/engineer)
- ❑ Pocket calculator
- ❑ Flashlight
- ❑ Penlight

- ❏ Camera
- ❏ Speed square
- ❏ Magnifying glass
- ❏ Thermometer
- ❏ Thickness gauge
- ❏ Protective clothing
- ❏ Hard hat
- ❏ Safety glasses
- ❏ Spud wrench
- ❏ Circuit tester
- ❏ Voltmeter
- ❏ Ampmeter
- ❏ Wire gauge
- ❏ Depth gauge

THINK SAFETY AT ALL TIMES

CHAPTER 2
DESIGN QUALITY CONTROL

DESIGN QUALITY CONTROL CHECKLISTS

It is estimated that more than 50% of the problems encountered on any given construction project could have been avoided if proper review and quality control procedures were implemented before the issuance of the plans or specifications. Most often, designers do not even read their own specifications. The most successfully implemented projects are those that allow time for thorough reviews and identification of potential problems. Listed next are some frequently encountered problems that arise from contract documents. Many are simply common sense; however, failure to adhere to them can result in project failures that could have been (and should have been) avoided!

OVERVIEW

- Work "by others" and work "this contract" are clearly differentiated and interface points identified.

- All known existing features and improvements are properly and completely delineated and dimensioned.
- Orientation, horizontal coordinate systems, elevations, and vertical datum are properly shown and referenced.
- Adequate subsurface investigations of the site have been made and logs and notes thereof are clearly shown on plans and referred to in specifications.
- The recommendations of the Geotechnical Report have been considered in establishment of control elevations, foundation treatment, and assignment of bearing values for footing design. (Who has ownership and responsibility for complying with the recommendations?)
- Adequate provisions have been made in the specifications for protection and maintenance of, access to, and utility services for existing facilities.
- All documents have been logically ordered and a table of contents provided.
- All documents, specifications, and plans have been dated and stamped by the designer!

- The scale and orientation of the drawings are consistent throughout the complete set of drawings.
- The Statement of Work (SOW) shown in the Request for Quotation (RFQ) has been passed through to the current design directives to the individual subcontractors.
- Annotated, approved comments from previous reviews, as well as correspondence and all meeting minutes, are included in the design.

PLANS AND SPECIFICATIONS

❑ All necessary details, notes, schedules, and dimensions are shown on the drawings and are fully consistent throughout.

Civil Details Required

- Gutter
- Storm drainage
- Drainage schedule
- Erosion control
- Manholes
- Meter/water vault
- Gas lines
- Oil separator
- Fire loop w/PIV, hydrants

- Steam/condensation lines
- Area to be cleared
- Fence and gates (size of post, gate type, and widths)
- Demolition areas
- Typical pavements
- Bollard locations
- Misc concrete pads
- Landscape plan and schedule

❏ Title blocks, drawing titles, drawing scales, and specification subtitles and section identification markings are shown and referenced.

❏ Requirements for installation of owner-furnished equipment are clearly delineated.

❏ Ample space allowances are available for installation and servicing of equipment.

❏ The terminology used on the drawings agrees with that used in the specifications and does not repeat requirements stated in the specifications.

❏ Finish and color schedules have been coordinated with drawings.

❏ When drawings are printed at full size, all lettering, dimensions, symbols, wiring and piping runs, etc. are clear and distinct.

- ❑ The drawings and specifications for all disciplines have been properly reviewed and coordinated to preclude conflicts.
- ❑ Complete legends for each discipline, including all symbols, are shown on the plans.
- ❑ North arrow and graphic/bar scales are shown correctly on all site plans.

CIVIL/SITE DESIGN CHECKLISTS

Civil Design

- ❑ Existing and finished grades are shown.
- ❑ Haul routes, disposal/borrow sites, construction contractor's storage area, construction limits, and construction staging area are shown.
- ❑ Existing utilities, sizes, and materials are shown.
- ❑ New underground utilities have been checked for conflicts against the site plans.
- ❑ Utility tie-in locations agree with mechanical stub-out plan.
- ❑ Profile sheets show underground utilities and avoid conflicts between new and existing.
- ❑ Property lines and limits of clearing, grading, turfing, or mulch have been shown and are consistent with architectural and/or landscaping plans.

- ❏ Fire hydrant and power/telephone pole locations correspond with electrical and architectural drawings.
- ❏ Basis of horizontal and vertical control is given, and the control points are located properly with pertinent data shown (for example, BM's/CP's elevations).
- ❏ Tops of valve boxes and manholes match finished grades, pavement, swales or sidewalks.
- ❏ Boring locations, soil classifications, water table, and depth of rock are shown on the plans or in the write-ups.
- ❏ Rigid pavement joint plans are shown with reasonable spacing.
- ❏ Foundation coordinates are shown on the foundation plan and coordinated with architectural drawings.
- ❏ Finished floor elevations match on architectural and structural drawings.
- ❏ Civil specifications are coordinated with plans.
- ❏ Storm and sewage drains from the facility have adequate capacity.
- ❏ Directions to contractors are not contradicted in plan notes and in the specifications.
- ❏ Removal, demolition plan(s) is (are) complete.

- ❏ Construction limit line is shown, including removal of existing pavements when required.
- ❏ Sufficient attention has been given to preserving the natural terrain and trees.
- ❏ Sufficient general notes, dimensions, and elevations are shown for proper construction layout, including construction baseline (B/L) on finish grade spot elevations are indicated on graded earth areas and along pavements on "Grading and Paving Plan."
- ❏ Slopes of paved surfaces and graded earth areas are satisfactory and within criteria of maximum and minimum grades to prevent ponding and ensure positive drainage to the desired surface inlet or drainage outlet.
- ❏ Typical full and partial sections through site are sufficiently detailed to show the relationship of finished floor elevation of building(s) to outside finished grades of both grassed and paved areas.
- ❏ The following typical sections are provided and adequately dimensioned:
  (a) Concrete pavement
  (b) Bituminous pavement
  (c) Sidewalks, entrance drives, and roads
  (d) Other sections, as required

- ❏ All applicable detail sketches and construction notes are shown for curb and gutter, storm drain inlets, manholes, headwalls, painting pavement markings, riprap, erosion control measures, and other required items of sitework. Appropriate specification sections are referenced when applicable.
- ❏ If the design includes concrete pavement, then the following must be shown:
  (a) Concrete joint layout plan:
    1. Concrete joint details and spacing.
    2. Type of joint material, as per specifications.
    3. Special details for reinforced concrete slab around storm drain inlets, when required.
    4. Reinforcement of odd-shaped slabs.
    5. Tie-down anchors, as required.
    6. Other details, such as ADA requirements, as required.
- ❏ "Storm Drainage Pipe Structures Schedule" shown in the drawing detail(s) agrees with the drainage plan, drainage design analysis, and pipe profile(s) regarding inlet numbers, invert elevations, etc.
- ❏ Plant schedule agrees with the landscape plans.

- ❏ Locations of all soil borings, test pits, etc. are correctly shown on the Grading Plan, and appropriate symbols included in legend.
- ❏ All applicable detail sketches and construction notes are shown for erosion control measures, and other required items of sitework are finalized in the Erosion Control Plan. Appropriate specification sections are referenced when applicable.
- ❏ Project-specific details are essential. Generic "boiler-plate" terms are not adequate.

Storm Drainage Design

- ❏ Analysis contains an introductory page giving a brief description of the general terrain and/or site soil conditions, drainage patterns, basis of technical requirements, and other pertinent data affecting the proposed storm drainage system (formula, appropriate rainfall and runoff criteria, etc.).
- ❏ Drainage area map is complete, with subareas outlined, including possible "offsite" drainage, and all necessary "existing" and "new" drainage pipe and structures are indicated.
- ❏ Drainage tabulation forms are complete, and calculations are included for:

(a) ditch flow and culverts, when required.
(b) capacity and spacing of inlet openings.
(c) correct pipe strength(s) (Gauges/ D-Loads).

Pavement Design Analysis

- ❏ Discussion of site conditions, etc. indicates that borings logs have been reviewed to ensure there are no unsuitable soils (heavy clays/organic soils) that would require removal and replacement in areas to be paved or in other critical areas. If these conditions exist, then provisions have been made for removal of same, and limits are shown on the drawings.
- ❏ Classifications of road usage, vehicle category, CBR/K values, and method of determining required pavement thickness and depths of compaction are satisfactory.
- ❏ The assumptions used in the pavement foundation analysis are consistent with the CBR values specified in the final foundation report.

Landscape Design

- ❏ The sprinklers, lighting, hardscape, etc. correspond with the site limits, including the building and civil plans.

- ❑ Maintenance of landscape (watering, fertilizing, etc.) has been provided for in the design documents.
- ❑ Where applicable, appropriate "General Notes" are provided on the drawing(s), indicating trees to remain within the designated grading limits.
- ❑ All required plant items are included on plant list, and shrubs, etc. comply with approved plant list in the original Request for Proposal and/or other documents.
- ❑ Planting details (depths, size of hole, etc.) are provided.

CIVIL/SANITARY DESIGN CHECKLISTS

Sanitary Sewers

- ❑ Utility plan(s) show all existing and new sanitary sewers including manholes and cleanout locations.
- ❑ Sizes of sanitary sewers are shown, and all work can be located in the field from established benchmarks (BMs) or baselines.
- ❑ Sanitary sewers are profiled, including building connections, and show pertinent data (existing and final grades, top and invert elevations, size, length, pipe crossing).

- ❏ Building connections have been coordinated with interior plumbing size, inlet elevations, and locations.
- ❏ Sanitary sewers do not conflict with other underground utilities.
- ❏ Sewers are laid at sufficient slope to provide minimum velocity when flowing full.
- ❏ Minimum-size sewer lines are shown for building sewers and for mains.
- ❏ Adequate cover for frost protection has been provided.
- ❏ Determination made to maintain flow in existing sewer system during construction of new sewers.
- ❏ Abandoned sewers are shown as plugged or removed.
- ❏ Sanitary sewer appurtenance details are provided.

Water

- ❏ Pipe size is adequate for domestic water demand.
- ❏ Gate valves and valve boxes are properly located.
- ❏ Pipe size is adequate for fire flow demand.
- ❏ Number and location of new and existing fire hydrants are sufficient for adequate fire protection.

- ❑ Fire line entering building agrees with interior sprinkler plan. Position indicator valve (PIV) is shown.

Design Analysis

- ❑ Domestic water line(s) have been sized on correct fixture unit basis.
- ❑ Velocity and head loss have been computed.
- ❑ Sanitary and waterline specifications include all items, sizes, and work shown on the contract drawings. Inapplicable paragraphs indicated as "Not Used" and inapplicable reference publications have been deleted.
- ❑ All allowed pipe material options have been retained and correct strength of pipe has been selected.
- ❑ Special construction requirements are shown on details are properly covered and resolved in the specifications.

ARCHITECTURAL DESIGN CHECKLIST

- ❑ Site property lines and existing conditions match survey or civil drawings.
- ❑ Building location meets all setback requirements, zoning codes, and deed restrictions.
- ❑ Building limits match civil, plumbing, and electrical on-site plans.

- ❏ Locations of columns, bearing walls, grid lines, and overall building dimensions match structure.
- ❏ Locations of expansion joints—all floors—match with structural drawings.
- ❏ All elevated concrete slabs have a shoring and reshoring plan.
- ❏ Demolition instructions are clear on what to remove and what is to remain, and are coordinated with design documents.
- ❏ Building elevations match floor plans and have the same scale.
- ❏ Building sections match elevations, plans, and structural drawings.
- ❏ Building plan match lines are consistent on structural, mechanical, plumbing, and electrical drawings.
- ❏ Structural member locations are commensurate architecturally.
- ❏ Elevation points match structural drawings.
- ❏ Chases match structural, mechanical, plumbing, and electrical drawings.
- ❏ Section and detail call-outs are correct and cross-referenced.
- ❏ Large-scale plans and sections match small-scale plans and sections.
- ❏ Reflected architectural ceiling plans are coordinated with mechanical and electrical plans.

- ❏ Columns, beams, and slabs are listed on elevations and sections.
- ❏ Door schedule information matches plans, elevations, fire rating, and project manual.
- ❏ Cabinets or millwork will fit in available space.
- ❏ Flashing through the wall and weep holes are provided where code requires.
- ❏ Areas above halls and rooms are coordinated with mechanical, plumbing, and electrical plans (above ceiling cross section).
- ❏ Flashing materials and gauges are indicated or specified.
- ❏ Fire ratings of walls, ceilings, and fire and smoke dampers are indicated or specified.
- ❏ Adequate clearances have been given for the maintenance of all mechanical/electrical equipment as per code.
- ❏ Miscellaneous metals are detailed, noted, and coordinated with the Project Manual.
- ❏ Equipment room or areas are sized commensurate with mechanical, electrical, and plumbing equipment.
- ❏ Limits, types, and details of waterproofing are coordinated with design documents.
- ❏ Limits, types, and details of insulation are coordinated with design documents.

- ❏ Limits, types, and details of roofing are coordinated with design documents.
- ❏ Skylight structures are compatible with structural, mechanical, and electrical designs.
- ❏ Piping loads hang from the roof or floors, and are coordinated with the mechanical and structural drawings, and proper inserts are called for on the drawings.
- ❏ Mechanical and electrical equipment is properly supported, and all architectural features are adequately framed and connected.
- ❏ All drawings showing monorails, hoists, and similar items have support details, notes, and the locations are coordinated with the architectural, structural, mechanical, and electrical drawings.
- ❏ Walls, partitions, and window walls are not inadvertently loaded through deflection.
- ❏ All window walls, expansions, and weeps are provided.
- ❏ All physically disabled requirements are coordinated with plumbing and electrical plans.
- ❏ Architectural space requirements are commensurate with ductwork, conduit, piping, light fixtures, and other recesses.

- ❑ Architectural space requirements are commensurate with elevators, escalators, and other equipment.
- ❑ Dew point in walls, roof, and terraces, and vapor barrier have been provided as required.
- ❑ Concealed gutters are properly detailed, drained, and waterproofed; expansion has been provided for.
- ❑ Compatibility of grading around perimeter of building has been established with civil drawings.
- ❑ Color finish schedules are on drawings.
- ❑ Interior valleys for buildings having large flat roofs are provided with saddles or crickets to eliminate formation of "bird baths."
- ❑ Project-specific rather than generic "boiler plate" details are shown.

STRUCTURAL DESIGN CHECKLIST

- ❑ The design load conditions meet or exceed the Building codes and the Design Standards.
- ❑ The column orientation and grid lines on the structural and the architectural drawings match.
- ❑ The load-bearing walls and the building column foundation locations match with architectural drawings.

- ❏ The slab elevations match the architectural drawings.
- ❏ The depressed or raised slabs are indicated and match the architectural drawings.
- ❏ The limits of slabs on the structural drawings match the architectural drawings.
- ❏ The expansion joints on the structural drawings match the architectural drawings.
- ❏ The footing depth and cover are shown with the existing and final grades.
- ❏ The foundation piers, footings, and grade beams are coordinated with schedules.
- ❏ The footing and pier locations do not interfere with new and existing utilities, trenches, and tanks.
- ❏ The foundation wall elevations are the same as those on the architectural drawings.
- ❏ The location of door and roof framing column lines and column orientation match the foundation plan column lines and column orientation.
- ❏ The structural perimeter floor and roof lines match the architectural drawings.
- ❏ The section and detail call-outs are proper and cross-referenced.
- ❏ The columns, beams, and slabs are listed in schedules and are coordinated.

- ❏ The column length, beam, and joist depths match those same dimensions in the architectural drawings.
- ❏ The structural dimensions match the architectural drawings.
- ❏ The drawing notes do not conflict with specifications.
- ❏ The architectural construction and rustication joints are correct.
- ❏ The structural openings are coordinated with the architectural, mechanical, electrical, and plumbing drawings.
- ❏ The structural joist and beam locations do not interfere with water closets, floor urinals, floor drains, and chases.
- ❏ The structural design of roof and floors considered the superimposed loads, including the HVAC equipment, boilers, glass walls, etc.
- ❏ Cambers, drifts, and deflections have been coordinated with the architectural drawings.
- ❏ The concentrated load points on joists do not conflict with design by other disciplines, i.e., large water lines or fire main lines.
- ❏ Horizontal and vertical bracing, ladders, stairs, and framing do not interfere with doorways, piping, duct work, electrical, equipment, etc.

- ❑ The structural fire proofing requirements are coordinated with the architectural requirements.
- ❑ Rock excavation is a base bid or a unit price.
- ❑ Project-specific rather than generic "boiler plate" details are shown.

MECHANICAL DESIGN CHECKLISTS

Mechanical Design

- ❑ Mechanical plans match architectural and reflected ceiling plans.
- ❑ HVAC ducts are commensurate with architectural space and are not in conflict with conduit, piping, etc.
- ❑ Mechanical equipment fits architectural space with room for access, safety, and maintenance.
- ❑ Mechanical openings match architectural and structural drawings.
- ❑ Mechanical motor sizes match electrical schedules.
- ❑ Thermostat locations are not placed over dimmer controls.
- ❑ Equipment schedules correspond to manufacturer's specifications and design documents.

- ❑ Mechanical requirements for special equipment (i.e., kitchen, elevator, telephone, transformers) are clear.
- ❑ Fire damper located in ceiling and fire walls.
- ❑ All structural supports required for mechanical equipment are indicated on structural drawings.
- ❑ All roof penetrations are shown on roof plans.
- ❑ Seismic bracing details are provided for all platforms that support overhead equipment and seismic flexible coupling locations and details are shown.

Fire Protection Design

- ❑ Waterflow testing for all new sprinkler systems are conducted and waterflow test data indicated on drawings or in specifications.
- ❑ Detailed hydraulic calculations are provided verifying that water supply is sufficient to meet fire protection system demand.
- ❑ Complete riser diagram is shown.
- ❑ All piping from the point of connection to the top of the sprinkler riser(s) is shown on the drawings.

- ❏ All valves, fire department connections, and inspector's test connections are indicated on the drawings.
- ❏ Sprinkler main drain piping and discharge point are shown and detailed, and main drains discharge directly to the outside.
- ❏ The extent or limit of each type of sprinkler system, each design density, each type and temperature rating of sprinkler heads, and location of concealed piping is clearly specified or shown.
- ❏ Water-filled sprinkler piping is not subject to freezing.
- ❏ Detail of the sprinkler piping entry into the building is provided and includes details of anchoring and restraints.
- ❏ Aesthetics considerations are incorporated in the design of the sprinkler system; e.g., the sprinkler piping is concealed in finished areas and recessed chrome-plated pendent sprinkler heads are used in finished area.
- ❏ Paddle-type waterflow switches are only used in wet-pipe sprinkler systems. (The other sprinkler systems use pressure-type flow switches.)
- ❏ The main sprinkler control valves are accessible from the outside.
- ❏ Fire rating of fire-rated walls, partitions, floors, shafts, and doors are indicated.

- ❏ If spray-applied fire proofing is specified, the fire rating of the steel structural members is indicated.
- ❏ Locations of required fire dampers are shown.
- ❏ Location of all fire alarm indicating devices, pull stations, waterflow switches, detectors and other fire alarm and supervisory devices are indicated on the drawings.
- ❏ The connection of the fire alarm and detection system to the installation-wide fire alarm system is clearly shown and detailed.

Fire Alarm Plan (code required)

The following specs/dimensions will complete your Fire Alarm Plan:

- Floor plan
- Locations of alarm-initiating and notification equipment
- Alarm control and trouble signaling equipment
- Annunciation
- Power connection
- Battery calculations
- Conductor type and sizes
- Voltage drop calculations
- Manufacturers, model numbers, and listing information for equipment, devices, and materials

- Details of ceiling height and construction.
- The interface of fire safety control functions.

Plumbing Design

- ❏ Plumbing plans match architectural, mechanical, and structural drawings.
- ❏ Plumbing fixtures match plumbing schedules and architectural locations.
- ❏ Compatibility of site piping limits interfaces with building piping.
- ❏ Roof drain locations coordinate with roof plan.
- ❏ Subsurface drains are located and detailed.
- ❏ Roof drain overflows are provided.
- ❏ Piping chase locations match architectural and structural drawings.
- ❏ All hot and cold water piping is insulated IAW, the contractor's approved piping insulation display sample.
- ❏ Piping is commensurate with architectural space and not in conflict with conduit, ducts, and structure elements.
- ❏ Piping openings match architectural and structural drawings.
- ❏ Complete riser plans are shown with *all* piping!
- ❏ Structural design is compatible with plumbing equipment and piping requirements.

- ❏ Plumbing equipment schedules correspond to manufacturers' specifications and design documents.
- ❏ Floor drains match architectural and kitchen equipment plans.
- ❏ Site utilities have been accurately verified, and site water and gas service requirements are met by supply utilities.
- ❏ Floor openings, i.e., drains, water closets, do not conflict with structural beams, joists, or trusses.
- ❏ Limits and confines where piping may be run are shown.
- ❏ Seismic bracing details are provided, and seismic flexible coupling locations are shown.
- ❏ Roof drain details are coordinated with other trades to show the installation of sump pans in ribbed sheet metal decks, and the placement of roof insulation in and around the drainage fitting.

Electrical Design

- ❏ Electrical plans match architectural, mechanical, plumbing, and structural plans.
- ❏ Location of light fixtures, speakers, etc. match with reflected ceiling plans.

- ❏ Electrical connections are shown for equipment, e.g., mechanical motors, heat strips, architectural, overhead doors, stoves, dishwashers, etc.
- ❏ Locations of panel boards and transformers are shown on architectural, mechanical, and plumbing plans.
- ❏ Conduit chase locations match with architectural and structural drawings.
- ❏ Compatibility of conduit and light fixtures with architectural space is met; no conflicts exist with duct, piping, or structure.
- ❏ Electrical equipment structural requirements have been met.
- ❏ Electrical equipment room fits architectural space, with clearance for safety and maintenance.
- ❏ Electrical voltage, phasing for all motors match on mechanical and architectural designs.
- ❏ Fixtures, speakers, clocks, etc. schedules correspond to a manufacturer's description and design documents.
- ❏ Light fixture spacing and location are arranged and specified to prevent dark spots.
- ❏ Location of duplex outlets, telephone, fire alarms, clock outlets, etc. with architectural millwork and finishes as indicated on plan.

- ❑ Limits and confines where conduits may be run have been verified.
- ❑ Site electrical and telephone service requirements have been verified with the supply utility.
- ❑ Seismic bracing details have been provided, and seismic flexible coupling locations have been shown.

DRAWING CHECKLIST

- ❑ All work depicted on drawings is readable at full size.
- ❑ New work is shown three pen weights heavier than existing construction.
- ❑ Overlays and base sheet are composited to check for duplication or overprinting of features, notes, plans, sections, and details.
- ❑ Titles, subtitles, scales, title block, and revision block information is complete and accurate.
- ❑ Titles of drawings agree with the titles listed on the Index of Drawings.
- ❑ The total number of drawings is on the first sheet of the set and is correct.
- ❑ The signature block is on the first sheet of each discipline.
- ❑ Drawings are consecutively numbered.
- ❑ All drawings are present.

- ❑ Site-adapted drawings have the appropriate notation in each revision block.
- ❑ Amended or modified drawings have the appropriate notation in each revision block.
- ❑ Symbols on drawings are standard and accompanied by the complete legend.
- ❑ The use of cross-referencing bubbles for locating sections, details, and elevations has been coordinated and explained.
- ❑ On the Final Design submittal, all title block numbering (Plate No., File No., Sheet No., and Ring No.) is in place.
- ❑ All final contract drawings are free of tape, appliques, and shading.
- ❑ Colored ink is not used on plotted drawings.
- ❑ Multiple drawing layers have been composited into either a single reproducible sheet or into one reproducible sheet per color overlay where color reproduction is planned.

SPECIFICATION CHECKLIST

- ❑ Project name, location, and project number are inserted as a main heading at the top of each subheading on the first page of each section.
- ❑ All "gaps" have been eliminated where material has been omitted from text.

- ❏ Other technical section(s) referenced within a section have been included, and either the section has been added or the paragraph rewritten to eliminate the reference.
- ❏ Omitted main paragraphs indicated as "NOT USED," and omitted subparagraphs indicated as "Not used."
- ❏ Consecutively omitted paragraphs are single spaced.
- ❏ All blanks have been filled in and all brackets removed.
- ❏ All tables have been printed on one page (unless it is physically impossible to fit the table on one page).
- ❏ If tables require more than one page, headings have been duplicated on second page.
- ❏ Margins are properly set a minimum of 25 mm (1 in) on all four sides of the sheet (right, left, top, and bottom).
- ❏ Page numbers are shown at least 12 mm (½ in) from the bottom of the page and prefixed with the section number.
- ❏ Page numbers are correct.
- ❏ Paragraphs numbers are connected.
- ❏ Submittal Register has been verified with the owner.
- ❏ Verify that all required sections of the project specifications have been included.

- ❏ Verify that the appropriate review level has been indicated for all submittals listed on the Contractor Submittal Register, and that the Register agrees with the technical specification sections.
- ❏ Require all engineering disciplines to review and sign off on a legal document that they have fully read all specifications, plans, and construction documents, and that to the best of their knowledge contains no errors or omissions and that adequate quality review has been completed. All reviews have been signed off by the Design Project Manager.

THINK SAFETY AT ALL TIMES

CHAPTER 3
PIPING SYSTEMS

COORDINATION OF WORK

This chapter covers piping for the water, gas, drainage, heating, fire sprinkler, and refrigeration/air-conditioning systems, and condensate (drainage) pipelines and site underground piping systems. Refrigerator/air-conditioning piping includes refrigerant, condenser, and chilled water pipelines. Drawings indicate general layout.

- ❑ Coordinate pipe and equipment space and the schedule for installation among the various subcontractors doing the work.
- ❑ Check and eliminate interference between electrical, mechanical, architectural, and structural features, especially in equipment rooms and in ceiling areas. This is especially important in hallway ceilings where the piping and equipment become congested.

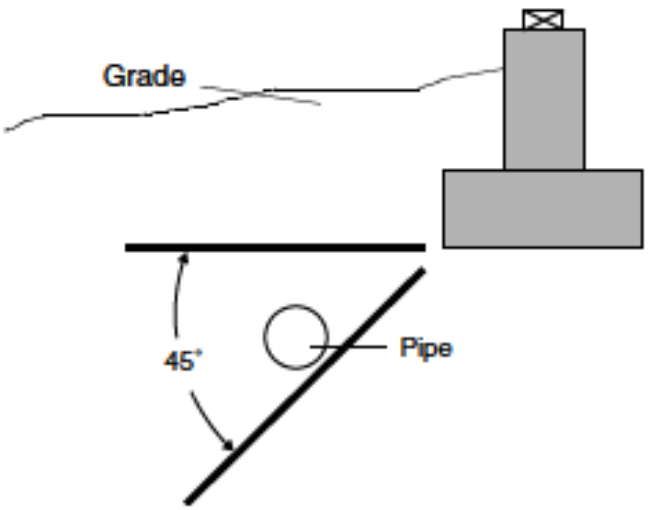
LAYOUT

- ❑ Review and approve equipment and mechanical room layout drawings, which

should be provided by the contractor. Coordination is required with other trades.

- ❏ Check pipe sleeve layout drawings for adequate depth, clearances, and proper sleeve sizes to include the pipe insulation thickness.
- ❏ Check layout for space to allow access and operation of all valves.
- ❏ Check layout for space to maintain and repair piping, especially at equipment locations.
- ❏ Check space for anchors and expansion loops.
- ❏ Check space for support of hangers for piping.
- ❏ Check for proper slope in pipe lines.
- ❏ Check that minimum overhead clearances are observed and ceiling heights are sufficient.
- ❏ Do not allow any cutting of any structural members without prior authorization.
- ❏ Ensure expansion joints are specified at building expansion joints.
- ❏ Ensure all piping is capped at the end of every workday.
- ❏ Check for adequate door and egress sizing to accommodate equipment replacement and/or upgrades for future expansion.
- ❏ Check for proper ADA (American Disability Act) restrictions for groundwork and rough-in locations.

- ❑ Ensure dissimiliar materials are joined using dielectric or insulating couplings.
- ❑ Ensure copper is protected when installed in metal studs.
- ❑ Check seismic zone locations for bracing requirements.
- ❑ Ensure that pipelines (except in sleeves) do not pass through footings (see Figs. 3-1 and 3-2). Locate pipelines beneath footings before the footings are placed. Verify frost depth.



- Underground piping cannot be supported by blocks or on rocks at any point.
- Backfill should be placed in 6-in. layers and tamped.
- Trenches need to be kept open until inspected.
- No rocks or other such type fill should be allowed until after 12 in. of fill.
- Water may be installed in same trench as sewer providing it is to the side and 12 in. separates the pipes.

Figure 3-1 FOOTER AND PIPING CLEARANCE

- ❑ Check equipment dimensions to ensure all equipment can be removed and replaced through the doorways provided, once the ceiling or roof is installed.

Note: Remember that all piping systems carrying liquids must be drainable.

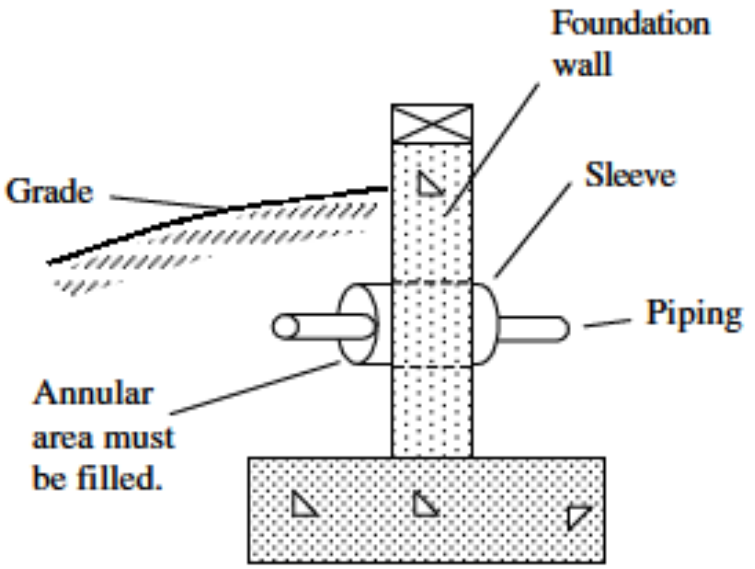


Figure 3-2 LAYOUT FOR PIPING SLEEVE IN FOUNDATION

Note: Do not allow the contractor to "drill" through the grade beams or concrete walls unless approved by the structural engineer.

THINK SAFETY AT ALL TIMES

CHAPTER 4
MATERIALS

SUBMITTALS

Submittals usually include information on compliance with specifications using labels, listings, or certificates. Shop drawings are required for layout of mechanical rooms and should include any special support for heavy piping and fittings.

- ❏ Consult the mechanical design engineer to check submittals for compliance with requirements.
- ❏ After determining that the submittal is in compliance, use its descriptive information to check the material at delivery. Use the layout drawings to check actual installation.
- ❏ Record all field changes if different from the layout. Verify that PM's (Project Manager) "red line" drawings are also updated.

STORAGE AND HANDLING

Materials must be handled safely and carefully to prevent damage.

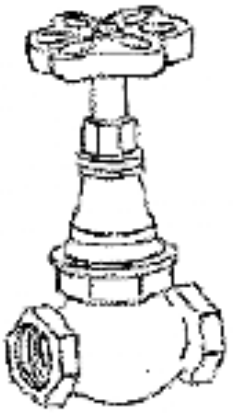
- ❏ Reject damaged materials. Mark them to make sure they are not used.

- ❏ Have damaged coatings repaired.
- ❏ Ensure proper handling for coated pipe.
- ❏ Do not allow PVC to be exposed to sunlight if not UV rated!
- ❏ Check for storage off of the ground and weatherproof storage when required.
- ❏ Store pipe and fittings to eliminate entry of dust, dirt, etc.
- ❏ Ensure that refrigerant pipe, which is cleaned and capped at the factory, remains capped until ready for use.
- ❏ Check for piping that is factory cleaned and purged with inert gas and capped. Check for gas-tight capping.

WATER PIPE AND FITTINGS

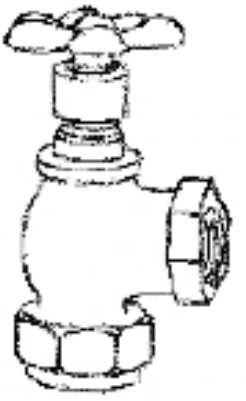
Pipe materials differ greatly for aboveground cold water pipelines (see Table 4-1 and Fig. 4-1). Many are plastic materials.

- ❏ Make sure that plastic pipes are not used in water systems for buildings greater than two stories in height.
- ❏ Make sure plastic type pipe does not extend through the roof or through fire-rated walls or floors.



Gate valve

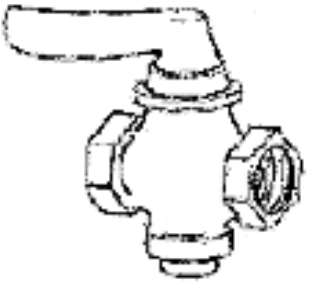
Globe valve



Angle valve

Stop-and-waste valve
(or bleeder valve)

Check valve



Straight stop
(for gas)

(Valves are not interchangeable, especially gate and globe valves)

Figure 4-1 COMMON VALVE TYPES

- ❑ Ensure seamless copper water tube is hard drawn: Type M for aboveground and Type L or K for belowground. Check specifications.
- ❑ Verify minimum and maximum water pressures.

TABLE 4-1 WATER SUPPLY AND DISTRIBUTION PIPING

Material	Standard
ABS plastic pipe (SDR-PR)	ASTM D 2282
ABS plastic pipe schedule 40 and 80	ASTM D 1527
CPVC plastic hot and cold water distribution systems	ASTM D 2846
CPVC plastic pipe schedule 40 and 80	ASTM F 441
CPVC plastic pipe (SDR-PR)	ASTM F 442
Cross-linked PE plastic hot and cold water distribution	ASTM F 877
Cross-linked polyethylene (PEX) tubing	ASTM F 876
Cross-linked polyethylene/aluminum/cross-linked polybutylene (PEX-AL-PEX) for water service and water distribution piping	ASTM F 1281
Ductile iron pressure pipe	ASTM A 377
PB plastic hot water distribution systems	ASTM D 3309
Polybutylene/aluminum/polyethylene (PE-AL-PE) for water service piping	ASTM F 1282
Polybutylene (PB) plastic pipe (SDR-PR) based on outside diameter	ASTM D 3000
Polybutylene (PB) plastic tubing	ASTM D 2666
Polybutylene (PB) plastic tubing	ASTM D 2737
Polyethylene (PE) plastic pipe (SDR-PR)	ASTM D 3000
Polyethylene (PE) plastic pipe controlled OD	ASTM D 2447
Polyethylene plastic pipe schedule 40	ASTM D 2104
Polyethylene plastic pipe (SDR-PR) controlled ID	ASTM D 2239
PVC plastic pipe schedule 40, 80, and 120	ASTM D 1785
PVC pressure-rated pipe (SDR series)	ASTM D 2241
Seamless brass type	ASTM B 135
Seamless copper tube	ASTM B 75
Seamless copper watertube Type K, L, and M	ASTM B 88
Seamless red brass pipe, standard sizes	ASTM B 43
Specification for polybutylene (PB) plastic pipe (SIDR-PR) based on controlled ID	ASTM D 2662
Welded copper water tube (WK, WL, WM)	ASTM B 447

Copper Pipes

Type K Has the thickest walls of the three types, usually used in underground locations.
Type L Has medium wall thickness. Mostly used as service to a home and for use in the interior distribution system.
Type M Has the thinnest wall and is available only in rigid, hard tempered. Used as general water distribution systems.

FUEL GAS PIPE AND FITTINGS

Fuel gas pipe and fittings must comply with all code requirements to include the Fuel Gas Code as given in National Fire Protection Association (NFPA) Standard No. V54.

- ❑ Check for permitted pipe options; either all or only steel, aluminum-alloy, metal tubing, or plastic materials may be specified.
- ❑ Check for specific materials required in insulating couplings.
- ❑ Ensure aluminum-alloy tubing and pipe are not permitted underground or at exterior locations.
- ❑ Ensure plastic pipe is not permitted in or under the building and is permitted only underground outside of the building.

❑ Check the specifications for ambient temperature limitations to the use of plastic pipe.

DRAINAGE PIPE AND FITTINGS, SEWER PIPING

Drainage pipe and fittings consist of the waste system, the storm drains and rainwater conductors, and the condensate drainage pipelines from air-conditioning and refrigeration units. There are many optional pipe materials (see Tables 4-2 and 4-3) and use is dependent on locations in the building and in the drainage system.

TABLE 4-2 APPROVED MATERIALS FOR DRAINAGE, WASTE, AND VENT PIPING

Material	Standard
Welded and seamless steel pipe (black or galvanized)	ASTM A 53
Cast-iron soil pipe and fittings (hub and spigot)	ASTM A 74
Cast-iron fittings (threaded)	ASTM A 126
Malleable iron fittings (threaded)	ASTM A 197
Seamless copper pipe	ASTM B 42
Seamless red brass pipe	ASTM B 43
Seamless copper tubing	ASTM B 75
Seamless copper water tubing (Type K, L, M)	ASTM B 88
ABS-DWV pipe and fittings	ASTM D 2661
PVC-DWV pipe and fittings	ASTM D 2665
3.25-in. OD PVC-DWV pipe and fittings	ASTM D 2949
ABS-DWV schedule 40 with cellular core	ASTM F 628
Coextruded PVC plastic pipe with cellular core	ASTM F 891

(continued)

TABLE 4-2 *(CONTINUED)*

Material	Standard
Coextended composite ABS-DWV pipe and fittings	ASTM F 1488
Cast-iron soil pipe and fittings (hubless)	CISPI 301
Copper drainage tube (DWV)	ASTM B 306
Mechanical couplings	CSA B602M
Solvent cement for ABS-DWV pipe and fittings	ASTM D 2235
Solvent cement for PVC-DWV pipe and fittings	ASTM D 2564
Socket bell for PVC-DWV pipe and fittings	ASTM D 2672
Primers for solvents	ASTM F 656
Hubless cast-iron soil pipe and fittings	ASTM A 888
Couplings used with hubless fittings	CISPI 310-95
Shielded couplings	ASTM C 1277
Coextruded composite ABS-DWV schedule 40 IPS pipe solvent cement fittings	ASTM F 1488 ASTM D 2235 ASTM D 2661 ASTM F 628
Coextruded composite PVC-DWV schedule 40 IPS pipe solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891
Coextruded composite PVC-DWV IPS pipe, DR-PS140, PS200 solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891

- ❑ Check for drainage pattern type fittings as they are required in the wet pipe portion of the waste system.
- ❑ Ensure that hubless cast-iron pipe is not used underground and is not permitted in crawl spaces.

TABLE 4-3 CODE APPROVED SEWER PIPING

Material	Standard
Cast-iron pipe and fittings	ASTM A 74
Cast-iron soil pipe and fittings for hubless sanitary system	CISPI 301
Seamless copper tube	ASTM B 75
Copper water tube	ASTM B 88
Concrete sewer, storm drain, and culvert pipe	ASTM C 14
Compression joints for vitrified clay pipe and fittings	ASTM C 425
Vitrified clay pipe and fittings	ASTM C 700
Bituminized fiber drain and sewer pipe	ASTM D 1861
ABS-DWV pipe and fittings	ASTM D 2661
PVC-DWV pipe and fittings	ASTM D 2665
ABS sewer pipe and fittings	ASTM D 2751
3.25-in. OD PVC-DWV pipe and fittings	ASTM D 2949
Type PSMIPVC sewer pipe and fittings	ASTM D 3034
Joints for drain and sewer plastic pipe using flexible elastomeric seals	ASTM D 3212
ABS schedule 40 DWV pipe with cellular core	ASTM F 628
Coextruded PVC schedule 40, PS50, or PS100 plastic pipe with cellular core	ASTM F 891
Copper drainage tube (DWV)	ASTM B 306
Mechanical couplings for drain waste and vent pipe and sewer pipe	CSA B602M
Solvent cement for ABS-DWV pipe and fittings	ASTM D 2235
Solvent cement for PVC-DWV pipe and fittings	ASTM D 2564

(continued)

TABLE 4-3 *(CONTINUED)*

Material	Standard
Socket bell for PVC-DWV pipe and fittings	ASTM D 2672
Primers for solvent-cemented PVC-DWV pipe and fittings	ASTM F 656
Couplings for hubless cast-iron soil pipe and fittings	CISPI 310
Shielded couplings joining cast-iron soil pipe and fittings	ASTM C 1277
Cast-iron soil pipe and fittings for hubless sanitary system	ASTM A 888
Coextruded composite ABS-DWV schedule 40 IPS pipe (solid or cellular core) solvent cement fittings	ASTM F 1488 ASTM D 2235 ASTM D 2661 ASTM F 628
Coextruded composite PVC-DWV schedule 40 IPS pipe (solid or cellular core) solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891
Coextruded composite PVC-DWV IPS-DR-PS in PS35, PS50, PS100, PS140, PS200 solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891
Coextruded composite ABS sewer and drain pipe DR-PS in PS35, PS50, PS100, PS140, PS200 solvent cement fittings	ASTM F 1488 ASTM D 2235 ASTM D 2751
Coextruded composite PVC sewer and drain pipe DR-PS in PS35, PS50, PS100, PS140, PS200 solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 3034 ASTM F 789

- ❑ Check for use of proper pipe and fittings in corrosive waste and vent systems.

HEATING PIPE AND FITTINGS

- ❑ Check for use of black steel pipe or copper tubing for low-temperature hot water pipelines.
- ❑ Ensure steam piping is black steel; ensure vent piping is the same type.
- ❑ Check for use of schedule 40 black steel in high-temperature pipelines of 2 in. and larger.
- ❑ Make sure welded joints are used for high-temperature water pipelines over ¾-in. diameter.

HYDRONIC PIPING

Hydronic piping (Table 4-4) is used in heating systems involving heat transfer by a circulating fluid in a closed system.

TABLE 4-4 HYDRONIC PIPING	
Material	**Approved Use**
Brass pipe	Aboveground
Brass tubing	Aboveground
Chlorinated Polyvinyl chloride (CPVC) pipe and tubing	Aboveground Embedded in radiant system Temperature < 180°F
Copper pipe	Aboveground
Copper tubing (Type K, L, or M)	Aboveground Embedded in radiant system
Cross-linked polyethylene (PEX) tubing	Embedded in radiant system Temperature < 180°F
Polybutylene (PB) pipe and tubing	Aboveground Embedded in radiant system Temperature < 180°F
Polyethylene (PE) pipe	Embedded in radiant system Temperature < 180°F Low temperature < 130°F
Steel pipe	Aboveground Embedded in radiant system
Steel tubing	Aboveground

REFRIGERATION AND AIR-CONDITIONING PIPE AND FITTINGS

❑ Check the steel pipe or the copper or steel tubing and fittings for intended service. Refrigerant service rating is required for lines carrying any type of refrigerant.

- ❏ Check for galvanized steel pipe or hard drawn copper tubing for condenser water lines. Lines 4 in. and larger require black steel which must be coated and wrapped for underground use.
- ❏ Check the type of piping specified for chilled water lines.
- ❏ Check the drainage lines for condensate water. Drainage lines are usually given in the plumbing section of the specifications or in notes on the drawings.
- ❏ Check for the correct use and placement of air vents.

INSULATIONS

Insulation guidelines are given in Table 4-5.

TABLE 4-5 MINIMUM PIPE INSULATION

System type	Fluid temperature (°F)	Runout (<12 ft)	*Insulation* ≤1 in.	*Insulation* 1.25–2 in.
Heat systems				
Steam and hot water				
Low pressure and temperature	201–250	1.0	1.5	1.5
Low temperature	120–200	0.5	1.0	1.0
Steam condensate	Any	1.0	1.0	1.5
Cooling systems				
Chilled water, refrigerant, or brine	40–55	0.5	0.5	0.75
	<40	1.0	1.0	1.50

Note: For piping >1 in. and exposed to outdoor ambient temperatures, add 0.5 in. to minimum insulation value.

FIRE SPRINKLER PIPE AND FITTINGS

The fire sprinkler system is designed to use a specific water supply and distribution for specific occupancy. More information can be found in National Fire Protection Association (NFPA) Standard No. 13.

- ❑ Ensure that materials are in accordance with approved submittals.
- ❑ Check for correct water supply and distribution for the sprinkler system.
- ❑ Approve the contractor's working plans and make sure they are used when installing the system. Ensure all changes are reflected on the record set of drawings kept by the contractor.

THINK SAFETY AT ALL TIMES

CHAPTER 5
INSTALLATION OF PIPING SYSTEMS

GENERAL INSTALLATION GUIDELINES

Laying underground pipelines is also covered in the "Up to Code" Sitework book.

- ❑ Ensure that installation of exposed pipelines inside the building follows building lines. The building structure cannot be cut or otherwise weakened for pipelines without prior approval.
- ❑ Check for required slope in horizontal runs. Liquid systems must be drainable.
- ❑ Check for drains at low points.
- ❑ Check for air cocks at high points.
- ❑ Check for required access to drains, air cocks, and valves.
- ❑ Check for contact between dissimilar metals such as copper to iron or steel. Isolation (separation) will be required. Dissimilar pipe must be coupled with dielectric connections.
- ❑ Check that hangers are the proper style, correct size, and at required intervals (see Table 5-1). Ensure ferrous hangers are coated where used against copper pipe. Size hangers to encompass the pipe insulation.

TABLE 5-1 HYDRONIC PIPING HANGER SPACING

Materials	Maximum horizontal	Maximum vertical
ABS	4	10
CPVC ≤ 1¼ in. pipe or tubing	3	5
CPVC ≥ 1 in. pipe or tubing	4	10
Copper pipe	12	10
Copper tubing (Type K, L, or M)	6	10
Polyethylene (PEX) tubing	2.67	4
Polybutylene (PB) pipe and tubing	2.67	4
Polyethylene (PE) pipe	2.67	4
Steel pipe	12	15
Steel tubing	8	10
PVC	4	10

- ❑ Ensure pipelines are restrained from lateral movement at trapeze.
- ❑ Ensure that wall or floor supports also restrain the pipeline from lateral movement.
- ❑ Check for support needs at each floor but not at more than 15-ft intervals.
- ❑ Check for extra hangers or supports required at fittings and devices. A hanger is required within 1 ft of each change of direction.

- ❏ Ensure suspended heavy pipelines have proper support without overloading support points:
  (a) Check excess loads on steel bar joints or beams.
  (b) Check a hanger load or multiple hangers at the same location with more than 100 pounds of load.
  (c) Where you find a suspicious condition, request a structural evaluation from the design engineer.
- ❏ Check for required anchors and expansion loops or joints, especially on long pipelines. Also check for approved guides at the expansion points.
- ❏ Check for union or flanged connections at equipment and elsewhere in order to break and repair or replace piping, etc.
- ❏ Check for proper size pipe sleeves. Sleeves should be large enough for the pipe insulation thickness when required.
- ❏ Ensure that pipe sleeves through waterproofing have a clamping device to hold the flashing.
- ❏ Make sure sleeves protrude above finished floor surfaces in wet areas. The annular space between pipe and sleeve must be sealed.

- ❑ Check for proper fireproofing of openings between pipes and fire-rated construction.
- ❑ Check that escutcheons are used around pipes penetrating finished surfaces.
- ❑ Make sure when piping passes through fire wall assemblies that it is appropriately caulked or sealed.
- ❑ Ensure the use of soft drawn copper tubing, as permitted, when not using fittings.
- ❑ Check procedures for bending steel pipe. Steel pipe bending with proper equipment is permitted in sizes to 4-in. diameter. The bend radius must be at least 6 times the pipe diameter.

PIPE CONNECTIONS—SCREWED

- ❑ Examine the threading operation:
  (a) Pipe must be square cut.
  (b) Proper reaming before threading is required.
  (c) Sharp cutters must be used so that threads are not shaved.
  (d) Tapered threads, not running threads, are required.
  (e) Thread run must be checked. Not more than three threads should be exposed after the connection is tight. The specifi-

cations may have a threading table you can refer to.

(f) Pipe must be cleaned of cutting oil and metal filings. This is critical for refrigerant lines.

(g) All floor surfaces should be protected. Use a sand box or other adequate protection under the threading and cutting operation.

(h) Plastic pipe and metallic tubing are not to be threaded.

❑ Examine screwed pipe connections:

(a) Approved thread lubricant or tape should be applied to male threads only. Some piping may not permit use of tape at screwed joints; check for requirements.

(b) Threads should be measured to ensure that they are the minimum length required by code.

(c) Connections should be tightened but not overtightened.

❑ Check for distorted valves. See that wrenches and not pliers are used on the end of valves being screwed onto the pipes in order to prevent damage to the valve bore. Do not screw pipes against the web of globe valves, nor against the underside of seat rings of gate valves.

- ❑ Use threaded connections to angle stops at plumbing fixtures.

PIPE CONNECTIONS—MECHANICAL

Mechanical couplings are usually permitted on ferrous metal pipelines in a building for domestic hot and cold water systems.

- ❑ Check the specifications and approved shop drawings for mechanical pipe connections.
- ❑ Check the gasket material. It must be compatible with the liquid or gas in the pipeline.
- ❑ Check proper alignment of flanges, couplings, and gaskets.
- ❑ Ensure that gaskets used with high-temperature water are of the metallic asbestos type.
- ❑ Do not use the drift pin or spud wrench handle (or other unapproved method) to align flanges.
- ❑ Make sure mechanical couplings and fittings are compatible and manufactured by the same concern.
- ❑ Ensure dissimilar metal connections have cathodetic protection from galvanic action.

PIPE CONNECTIONS—HUB AND HUBLESS TYPES

- ❑ Check for proper rubber gasket installation in the hub or bell. The spigot end must be seated into the hub.
- ❑ When molten lead is used to make the joint, check the following:
  - (a) Jute must be compacted into the base of the joint to seal the end, and to center the spigot end in the hub.
  - (b) Proper depth of the joint is needed.
  - (c) Pouring the molten lead joint should be a continuous operation.
  - (d) The lead must be caulked with proper size irons.
  - (e) Each joint should be caulked at least three times around.
- ❑ Ensure that a hubless joint uses a rubber sleeve with stainless steel band. The assembly must be approved by the Cast Iron Soil Pipe Institute (CISPI).
- ❑ Check for proper torque wrench setting to 5 ft lb for tightening the stainless steel band in hubless joints.

PIPE CONNECTIONS—SOLDERED

- ❑ Ensure surfaces of the fitting and pipe are cleaned to bright metal with an abrasive material before the joint is made.
- ❑ Check lead solder percentages in water piping. Code allows a maximum of 0.2%.
- ❑ Check that the appropriate type of solder is specified:
  (a) The 50/50 solder is half tin/half lead and can be used in drainage, waste, and vent (DWV) pipelines.
  (b) Silver solder is 95/5, 95% tin and 5% antimony, and must be used in all other pipelines.
- ❑ Check soldering temperature specifications: ~400°F for soft solder and 1150°F for silver solder.
- ❑ Check for use of a multiflame torch for uniformly heating joints where 2½ in. diameter and larger pipe are soldered.
- ❑ Verify with the specifications and code that medical gas piping requires a certified welder or brazer.

PIPE CONNECTIONS—SOLVENT CEMENT (ADHESIVE)

- ❑ Check that compatible materials are used for plastic pipe connections.
- ❑ Ensure that adhesives are used in accordance with the pipe manufacturer's instructions.
- ❑ Make sure different kinds of plastic pipe are not joined together unless they are approved compatible.
- ❑ Make sure only a heat-fusion connection is used to join polyethylene pipe, tubing, or fittings.
- ❑ Ensure that the manufacturer's instructions are strictly followed.

PIPE CONNECTIONS—WELDED

- ❑ Check for use of welding fittings. Making fittings by notching or mitering pipe is not permitted.
- ❑ Check for the approved welding procedures before welding begins.
- ❑ Check for the individual welder certification in the type welding each welder must perform.
- ❑ Check welding of refrigerant pipe as the fittings and pipe must be filled with inert gas, such as nitrogen, during welding. This prevents the formation of scale inside the pipe.

- ❏ Ensure that welding for fire sprinkler systems is performed in a shop and in accordance with NFPA 13 requirements. Job site welding is generally not permitted.
- ❏ Check the "Up to Code" Structural Steel book for additional information on welding.

FITTINGS AND VALVES

- ❏ Check riser diagrams and floor plans on drawings for proper valve locations.
- ❏ Check that valves are the proper type.
- ❏ Make sure valves are oriented with stems in the horizontal position or above. Only the horizontal position is allowed for refrigerant pipelines.
- ❏ Check directional valves for proper orientation in the pipeline flow. Check and globe valves have an arrow cast in the housing to indicate direction of flow.
- ❏ Check for access to all valves. Access locations should be marked on ceiling panels. Also, make any changes to the record set of construction drawings.
- ❏ Make sure dielectric or insulated connectors are used where required at locations where different metals connect together in the pipeline.

PIPELINES

Water Pipelines

- ❑ Check that air chambers are installed at fixtures. Alternatively, check that water hammer arrestors are shown instead of air chambers.
- ❑ Check riser diagrams on the drawings for locations and sizes of these arrestors.
- ❑ Check that valves are located as shown and are accessible.
- ❑ Verify that the water service has a gate valve and drain at its point of building entry.
- ❑ Check for use of a backflow prevention device in each branch waterline connected to another system.
- ❑ Check for a vacuum breaker to prevent back-siphonage at each fitting or fixture with hose connection.
- ❑ Verify that pipes and fittings are of required material, type, size, etc., located and installed as required.
- ❑ Verify that non-lead solder is used. Code requires <0.2% lead content.
- ❑ Make sure exterior lines are installed to depth required, properly bedded and backfilled. Check that thrust blocks are provided as required. Coordination is made for meters, shutoffs, hydrants, boxes, etc.

- ❏ In large structures, make sure shutoff valves are provided if required to isolate portions of system.
- ❏ Ensure rough-ins to fixtures and equipment are located and installed as required.
- ❏ Ensure valves for proper function are used as required, and that location and accessibility are understood.
- ❏ Verify location and type of access panels. See that the water system can be drained at the lowest point. Make sure all valves are labeled if required.
- ❏ Check that air chambers or shock absorbers are provided if required.
- ❏ Check that sound and vibration isolators are provided as required.
- ❏ Make sure dielectric fittings are provided for connection of dissimilar metals.
- ❏ Check that allowance for expansion and contraction is provided.
- ❏ Make sure system is tested before concealment or installation of insulation. Observe the testing process.
- ❏ Verify that the insulation is of the required size, weight, thickness, and type and is installed as required.
- ❏ Verify that lines are identified as required.
- ❏ Make sure lines are sterilized as required, checking for proper dosage, distribution,

retention, and final flush-out. Certification should be provided.

Fuel Pipelines

- ❑ Check that general guidelines for fuel pipelines have been followed:
  (a) Avoid installation under buildings. Fuel gas service should be installed below grade on the outside.
  (b) Do not install service pipeline in the trench with other utilities.
  (c) Do not embed gas pipelines in solid walls and partitions.
  (d) Do not permit soldered joints. Use pressure-threaded joints for copper pipe.
- ❑ When piping is to be embedded in concrete, check for special requirements such as:
  (a) The design should be acceptable to the gas service company.
  (b) The concrete mix should be compatible with the pipe material. Certain concrete additives and aggregates may not be compatible.
  (c) Piping should not be allowed to touch dissimilar material such as rebar.
- ❑ Check for protective coating requirements on underground metallic pipelines.

- ❏ Where piping must be buried under the building, ensure it is encased in a gas-tight conduit for its full length of run. The space between the pipe and conduit must be safely vented to the atmosphere. Check the codes and specifications.
- ❏ Check for pipe slope and for the presence of drains at low points.
- ❏ Check for required pipeline bonding and grounding in accordance with the National Electric Code. See UP TP Code Electrical.
- ❏ Check for shutoff valves as required.
- ❏ Make sure that all fuel lines are visibly marked.

Code-Approved and Disapproved Fuel Gas Piping

Defects in pipe, tubing, or fittings shall not be repaired. Defective pipe, tubing, and fittings shall be replaced.

Cast iron Cast-iron pipe shall not be used!

Steel Steel and wrought-iron pipe shall be at least of standard weight (Schedule 40) and shall comply with one of the following standards:

1. ASME B 36.10, 10M
2. ASTM A 53
3. ASTM A 106

Copper and brass Copper and brass pipe shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas. Threaded copper, brass, or aluminum-alloy pipe in iron pipe sizes shall be permitted to be used with gases not corrosive to such material.

Aluminum Aluminum-alloy pipe shall comply with ASTM B 241 (except that the use of alloy 5456 is prohibited), and shall be marked at each end of each length indicating compliance. Aluminum-alloy pipe shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation and where it is subject to repeated wettings by such liquids as water, detergents, or sewage. Aluminum-alloy pipe shall not be used in exterior locations or underground.

Metallic tubing Seamless copper, aluminum-alloy, or steel tubing shall be permitted to be used with gases not corrosive to such material.

Copper tubing Copper tubing shall comply with standard Type K or L of ASTM B 88 or ASTM B 280.

Steel tubing Steel tubing shall comply with ASTM A 254 or ASTM A 539.

Copper and brass tubing Copper and brass tubing shall not be used if the gas contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas.

Aluminum alloy Aluminum-alloy tubing shall be coated to protect against external corrosion where it is in contact with masonry, plaster, or insulation or where it is subject to repeated wettings by such liquids as water, detergent, or sewage. Aluminum-alloy tubing shall not be used in exterior locations or underground.

Aluminum tubing Aluminum-alloy tubing shall comply with ASTM B 210 or ASTM B 241.

Corrugated stainless steel tubing Corrugated stainless steel tubing shall be tested and listed in compliance with the construction, installation, and performance requirements of ANSI/AGA LC 1.

Plastic pipe, tubing, and fittings Plastic pipe, tubing, and fittings shall be used outside underground only and shall conform with

ASTM D 2513. Pipe shall be marked "gas" and "ASTM D 2513."

Anodeless risers Plastic pipe, tubing, anodeless risers shall comply with the following:

- Factory-assembled anodeless risers shall be recommended by the manufacturer for the gas used and shall be leak tested by the manufacturer in accordance with written procedures.
- Service head adapters and field-assembled anodeless risers incorporating service head adapters shall be recommended by the manufacturer for the gas used by the manufacturer and shall be designed certified to meet the requirements of Category 1 of ASTM D 2513
- The manufacturer shall provide the user qualified installation instructions as prescribed by the U.S. Department of Transportation, Code of Federal Regulations, Title 49, Part 192.283(b).

LP-gas systems The use of plastic tubing, pipe, and fittings in undiluted liquefied petroleum gas piping systems shall be in accordance with NFPA 58.

Protective coating Where in contact with a material or an atmosphere exerting a corro-

sive action, metallic piping and fittings coated with a corrosion-resistant material shall be used.

Damaged threads Pipe with threads that are stripped, chipped, corroded, or otherwise damaged shall not be used. If a weld is damaged during the operation of cutting or threading, that portion of the pipe shall be rejected (not repaired).

Number of threads Field threading of metallic pipe is shown in Table 5-2.

Workmanship and defects Pipe or tubing and fittings shall be clear and free from cutting burrs and defects in structure or threading, and shall be thoroughly brushed, and scale or chip blown.

Used materials Pipe, fittings, valves, or other materials shall not be used again unless they have been approved for the service intended.

TABLE 5-2 FUEL GAS THREADING SPECIFICATIONS FOR METALLIC PIPE

Iron pipe (in.)	Length of threaded portion (in.)	Approximate no. of threads to cut
½	¾	10
¾	¾	10
1	⅞	10
1¼	1	11
1½	1	11

GAS PIPING INSPECTION METHODS

- Approved gases for testing gas piping include air, carbon dioxide (CO_2), and nitrogen (N_2).
- Piping systems should withstand a pressure of 10 psi for not less than 15 minutes.
- Welded pipe with pressures exceeding 14 in. water column require a test pressure of 60 psi for a minimum of 30 minutes.
- Gas meters need to be at least 3 ft away from sources of ignition when installed indoors.
- Used piping may be used for gas if free from defects.
- Piping supports should be spaced properly (see Table 5-3).

TABLE 5-3 PIPING SUPPORT FOR STEEL PIPING FOR GAS	
Piping	**Spacing (ft)**
Rigid, ≤¾ in.	10
Rigid, ≥1 in.	12
Tubing, ≤1½ in.	6

- Do not use plastic for gas piping in or under a house.
- Gas shutoff valves need to be within 6 ft of the appliance and in same area.
- All fuel-gas appliances need a cutoff valve.
- Fireplace gas shutoffs need to be within 4 ft of the appliance.
- Pipe joints need tape or joint compound (on male adapter only).
- Fittings for steel gas pipe need to be copper, brass, or bronze.
- Connectors cannot be over 3 ft in length, except for dryers and ranges where they may reach 6 ft.
- Outdoor appliances may have a gas hose not to exceed 15 ft.
- Metallic gas piping needs to be buried at least 12 in. below grade.
- Plastic piping needs to be buried at least 16 in. below grade.
- Plastic piping must have a no. 18 awg yellow wire with the ends exposed.

- Dissimilar piping needs to be joined by approved dialectic fittings and couplings.
- Plastic to metal connections should be made only underground and only outside the house, with approved fittings.
- Piping through concrete or masonry walls need to be enclosed in a sleeve.
- A “dirt” leg (sediment trap) should be installed as close to the appliance as possible. A dirt leg is not needed with ranges, clothes dryers, or outdoor grills.
- Gas piping cannot run through air plenums, air ducts, dumbwaiters, elevator shafts.
- Ok for combustible air ducts.
- Gas pipe unions not allowed in concealed areas.
- Piping in concrete slabs needs a minimum of 1½ in. concrete coverage and cannot come in contact with rebar and/or wire mesh.
- All gas piping needs to supported by fabricated materials compatible with the piping material.
- Field wrap of piping is needed when in contact with material that will corrode the material.
- Fuel piping cannot be located in a concrete slab that contains a quick set additive such as calcium.

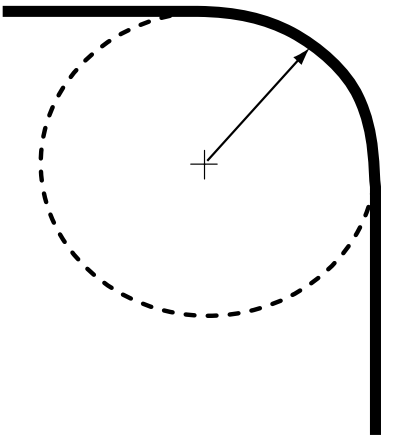


Figure 5-1 PIPING BENDS

TABLE 5-4 METALLIC PIPE BENDING

Diameter (in.)	Minimum bend radius = 6 times the diameter (in.)
⅜	2¼
½	3
¾	4½
1	6
1¼	7½
1½	9
2	12
2½	15
3	18
3½	21
4	24
5	30
6	36

- Tanks require a minimum spacing of 10 ft from any part of the dwelling.

Metallic Tubing for Gas

- Tubing should be free of all buckling when bent.
- The inside radius of a bend must be less than six times the tubing outside diameter (see Fig. 5-1 and Table 5-4).

Plastic Piping for Gas

- The inside bend radius should not be less than 25 times the outside diameter of pipe (see Table 5-5).
- Tubing in studs, joist, or any framing member needs shielding by 16-gauge plate if within 5 in. of each side of the framing member.
- All gas piping needs to be purged and have caps placed on them until they are attached to the appliance.
- Gas piping must be marked if not black steel piping.
- The marking is not required to be in same room as the appliance.
- Piping should be marked at 5-ft intervals where exposed.

TABLE 5-5 PLASTIC PIPE BENDING	
Diameter (in.)	Minimum bend radius = 25 times the diameter (in.)
⅜	9⅜
½	12½
¾	18¾
1	25
1¼	31¼
1½	37½
2	50
2½	62½
3	75
3½	87½
4	100
5	125
6	150

- Gas piping needs to be sized accordingly to the required demand of the appliance(s).

GAS PIPE SIZING

The capacity of gas piping systems can be estimated as follows:

- Find the most remote demand from the manufacturer's date plate. If unknown you can

use Table 5-6, which lists demands for some of the more typical gas-burning appliances.

- Work back picking up additional gas demands.
- Add up the values for the branch you are working on and then divide that number by the heating value (average Btu per cubic foot of gas). This value can be obtained from the supplier.

TABLE 5-6 TYPICAL GAS DEMANDS

Appliance	Btu input (approximate)
Range	65,000
Oven (built-in)	25,000
Top unit (built-in)	40,000
Water heater, 30–40 gallons	45,000
Water heater, 50 gallons	55,000
Automatic water heaters	
2 gallons/minute	142,800
4 gallons/minute	285,000
6 gallons/minute	428,400
Clothes dryer	35,000
Gas light	2,500

Note: For smooth wall semirigid tubing and corrugated stainless steel tubing consult the additional tables in the international codes.

- Repeat the above steps for any piping branching off.
- Use Tables 5-7 through 5-10 to verify that system capacity is sufficient to meet demand.

TABLE 5-7 APPROXIMATE PIPE SIZING PER BTU

Pipe length (ft)	*BTU's for diameter (in.) of*			
	½	¾	1	1¼
10	174	363	684	1404
20	119	249	470	965
30	96	200	377	775
40	82	171	323	663
50	73	152	286	588
60	66	138	259	532
70	61	127	239	490
80	56	118	222	456
90	53	111	208	428
100	50	104	197	404
125	44	93	174	358
150	40	84	158	324
200	34	72	135	278
250	30	64	120	246

TABLE 5-8 MAXIMUM GAS CAPACITY (CU FT) OF PIPE FOR GAS

Pipe length (ft)	*Nominal iron pipe size (in.)*					
	¼	⅜	½	¾	1	1¼
10	43	95	175	360	680	1400
20	29	65	120	250	465	950
30	24	52	97	200	375	770
40	20	45	82	170	320	660
50	18	40	73	151	285	580
60	16	36	66	138	260	530
70	15	33	61	125	240	490
80	14	31	57	118	220	460
90	13	29	53	110	205	430
100	12	27	50	103	195	400

Note: For gas pressure of 0.5 psi or less, 0.60 specific gravity gas. The International Fuel Gas Code will allow the above table to be used for specific gravity of 0.70 or less. If it is greater than 0.60 the cubic foot of gas values in the table above need to be adjusted by the multiplier identified in Table 5-9.

TABLE 5-9 MULTIPLIERS TO BE USED WHEN SPECIFIC GRAVITY IS GREATER THAN 0.60	
Gas specific gravity	Multiplier
0.65	0.96
0.70	0.93
0.75	0.90
0.80	0.87
0.85	0.84
0.90	0.82
1.00	0.78
1.10	0.74
1.20	0.71
1.30	0.68
1.40	0.66
1.50	0.63
1.60	0.61
1.70	0.59
1.80	0.58
1.90	0.56
2.00	0.55
2.10	0.54

TABLE 5-10 PIPE SIZING FOR 2 PSI CAPACITY PIPES (CU FT/HOUR)

Pipe length (ft)	*Schedule 40 pipe size (in.)*			
	½	¾	1	1¼
10	1506	3041	5561	11415
20	1065	2150	3932	8072
30	869	1756	3211	6591
40	753	1521	2781	5708
50	673	1360	2487	5105
60	615	1241	2270	4660
70	569	1150	2102	4315
80	532	1075	1966	4036
90	502	1014	1854	3805
100	462	934	1708	3508

Note: For an initial pressure of 2.0 psi with a 1.0 psi pressure drop. For smooth wall semirigid tubing and corrugated stainless steel tubing consult the additional tables in the international codes.

CODE-APPROVED FUEL STORAGE

- If underground, fuel storage should be located at least 10 ft from buildings.
- The maximum amount of fuel oil stored in the building or above ground is limited to 660 gallons.
- Underground oil tanks within 1 ft of property lines, foundations, or basement walls must be protected.

- Aboveground oil tanks must be at least 5 ft from property lines.
- Oil tanks need at least 1 ft of covering.
- Inside oil tanks require a gauge.
- Connections of combustible materials are not permitted within the building or aboveground outside the building.
- Oil piping to appliances cannot be less than ⅜ in. in diameter.
- Vent piping must not be less than 1¼ in. in diameter.
- Vent piping cannot terminate within 2 ft of any building opening.
- Shutoff valves are needed between the tank and the appliance.
- The oil pressure should not exceed 3 psi at the inlet to an appliance.
- Siting of containers and portable tanks should follow the guidelines in Tables 5-11 and 5-12.

TABLE 5-11 OUTDOOR LIQUID STORAGE IN CONTAINERS AND PORTABLE TANKS

Class of liquid	Maximum per pile		Minimum distance between piles	Minimum distance to lot line of property
	Quantity (gallons)	Height (ft)	(ft)	(ft)
IA	1,100	10	5	50
	2,200	7	5	50
IB	2,200	12	5	50
	4,400	14	5	50
IC	4,400	12	5	50
	8,800	14	5	50
II	8,800	12	5	25
	17,600	14	5	25
III	22,000	18	5	10
	44,000	14	5	10

Note: If protection by a public fire department or private fire brigade capable of providing cooling water streams is not available, the distance should be doubled.

When the total quantity stored does not exceed 50% of the maximum allowed per pile, the distances are allowed to be reduced 50%, but they should not be less than 3 ft.

TABLE 5-12 LOCATION OF LP-GAS CONTAINERS		
	Minimum separation between containers and public ways, buildings, or lot lines of adjoining property	
Container capacity (water gallons)	Mounded or underground containers (ft)	Aboveground container (ft)
Less than 125	10	5
125–250	10	10
251–500	10	10
501–2000	10	25
2001–30,000	50	50
30,001–70,000	50	75
70,001–90,000	50	100
90,001–120,000	50	125

- The minimum distance for underground LP-gas containers should be measured from the pressure relief device and the filling or liquid-level gauge vent connection at the container, except that all parts of an underground container shall be 10 ft or more from a building or lot line of adjoining property which can be built upon.
- Recommendations in Table 5-12 are for other than installations in which the over-

hanging structure is 50 feet or more above the relief-valve discharge outlet. In applying the distance between buildings and ASME containers with a water capacity of 125 gallons or more, a minimum of 50% of this horizontal distance shall also apply to all portions of the building which project more than 5 ft from the building wall and which are higher than the relief valve discharge outlet. This horizontal distance shall be measured from a point determined by projecting the outside edge of such overhanging structure vertically downward to grade or other level upon which the container is installed. Distances to the building wall should not be less than those prescribed in Table 5-12.

- LP-gas containers of less than 125 gallons water capacity are allowed next to the building they serve when in compliance.

THINK SAFETY AT ALL TIMES

CHAPTER 6
FUEL APPLIANCE INSTALLATIONS

GAS APPLIANCE TYPES

Category I These appliances operate with a nonpositive vent connection pressure and with a flue gas temperature of at least 140°F above its dewpoint.

Category II These appliances operate with a nonpositive vent connection pressure and with a flue gas temperature less than 140°F above its dewpoint.

Category III These appliances operate with a positive vent pressure and with a flue gas temperature at least 140°F above its dewpoint.

Category IV These appliances operate with a positive vent pressure and with a flue gas temperature less than 140°F above its dewpoint.

CLEARANCES AND PROTECTIONS

Recommended clearances for gas appliances (see Figure 6-1) are given in Tables 6-1 to 6-5. See Table 6-6 for code-approved protection materials.

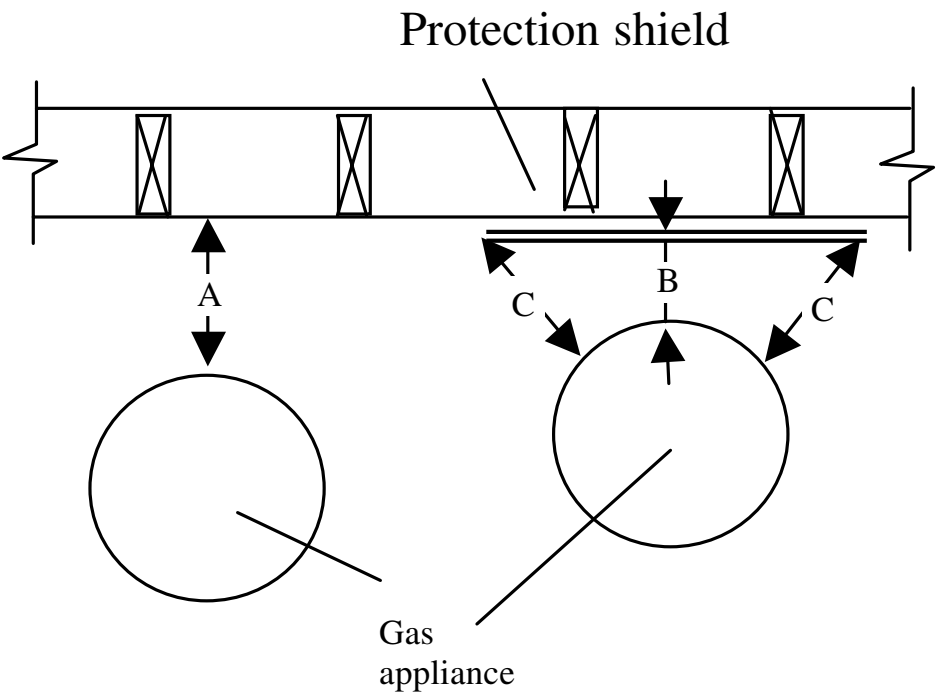


Figure 6-1 CLEARANCE FROM COMBUSTIBLE MATERIALS

- A is equal to clearance allowed with no protection.
- B is the "reduced clearance" as shown in Tables 6-1 to 6-5.
- C is the distance the protective method must extend and equals the original "unprotected" distance A.

TABLE 6-1 REDUCED CLEARANCES FOR GAS APPLIANCES FOR A = 36 IN.		
Type of protection	Above (in.)	Sides and rear (in.)
0	N/A	24
1	24	18
2	18	12
3	N/A	12
4	18	12
5	18	12
6	18	12
7	18	12

Note: The original required clearance A is 36 in. (see Figure 6-1). N/A, Not applicable.

TABLE 6-2 REDUCED CLEARANCES FOR GAS APPLIANCES FOR A = 18 IN.		
Type of protection	Above (in.)	Sides and rear (in.)
0	N/A	12
1	12	9
2	9	6
3	N/A	6
4	9	6
5	9	6
6	9	6
7	9	6

Note: The original required clearance A is 18 in. N/A, Not applicable.

TABLE 6-3 REDUCED CLEARANCES FOR GAS APPLIANCES FOR A = 12 IN.

Type of protection	Above (in.)	Sides and rear (in.)
0	N/A	9
1	9	6
2	6	4
3	N/A	6
4	6	4
5	6	4
6	6	4
7	6	4

Note: The original required clearance A is 12 in. N/A, Not applicable.

TABLE 6-4 REDUCED CLEARANCES FOR GAS APPLIANCES FOR A = 9 IN.

Type of protection	Above (in.)	Sides and rear (in.)
0	N/A	6
1	6	5
2	5	3
3	N/A	6
4	5	3
5	5	3
6	5	3
7	5	3

Note: The original required clearance A is 9 in. N/A, Not applicable.

TABLE 6-5 REDUCED CLEARANCES FOR GAS APPLIANCES FOR A = 6 IN.		
Type of protection	Above (in.)	Sides and rear (in.)
0	N/A	5
1	4	3
2	3	3
3	N/A	6
4	3	2
5	3	3
6	3	3
7	3	3

Note: The original required clearance A is 6 in. N/A, Not applicable.

TABLE 6-6 TYPES OF PROTECTIONS ALLOWED BY CODE

Type	Material
0	3.5-in.-thick masonry without air space
1	0.5-in.-thick insulation board over 1-in. glass fiber or mineral wool
2	0.024-in.-thick sheet metal over 1-in. glass fiber or mineral wool reinforced with wire on the rear face and with a ventilated air space (spacers are to be noncombustible and not located directly behind the appliance or vent)
3	3.5-in.-thick masonry with air space
4	0.024-in.-thick sheet metal with ventilating air space (at least 1 in. ventilating air space)
5	0.5-in.-thick insulation board with at least 1 in. air space
6	0.024-in.-thick sheet metal with 1 in. air space over an additional 0.024-in.-thick piece of sheet metal
7	1-in. glass fiber or mineral wool sandwiched between two sheets of 0.024-in.-thick sheet metal with ventilating air space

Note: Mineral wool batts are to have a density of 8 pounds per cubic foot and a minimum melting point of 1500°F (816°C).

VENTING GAS APPLIANCES

Venting of fuel-gas appliances is covered in greater detail in the "Up to Code" HVAC book.

General roof terminations for vents and chimneys are shown in Figures 6-2 and 6-3. Roof clearances for capped gas vents are given in Table 6-7. For common venting systems, refer to

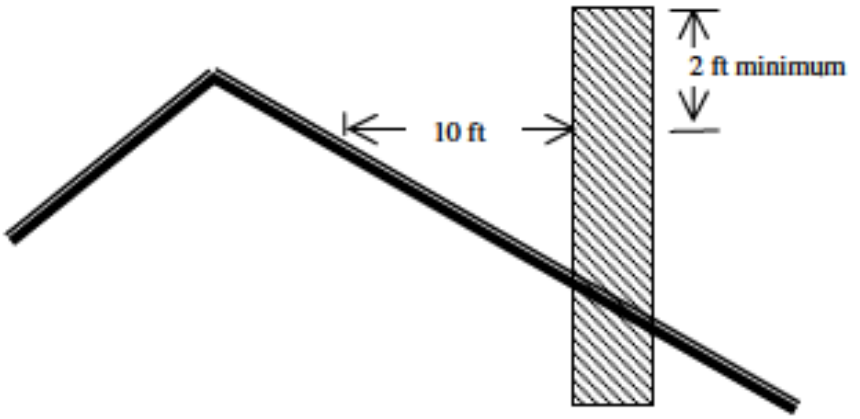


Figure 6-2 ROOF TERMINATIONS FOR CHIMNEYS AND SINGLE-WALL VENTS (NO CAPS)

Figures 6-4 to 6-10. Venting system clearances are specified in Tables 6-8 to 6-10.

- Vents that pass through insulation require a shield of at least 26 gauge sheet metal. In attics the shield is to extend at least 2 in. above the level of insulation.

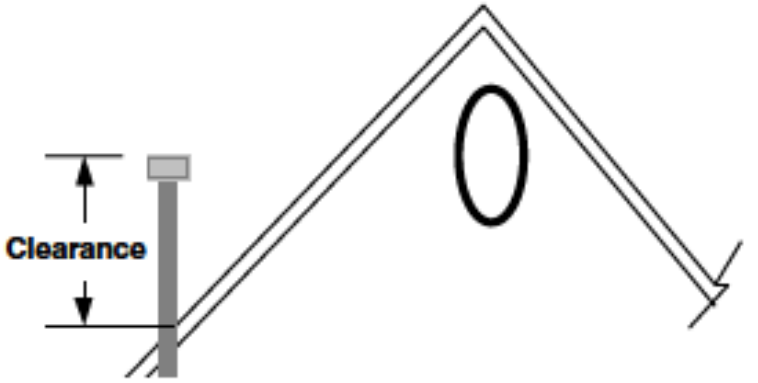


Figure 6-3 ROOF TERMINATIONS FOR CAPPED GAS VENTS

TABLE 6-7 GAS VENT TERMINATIONS FOR LISTED VENT CAPS

Roof slope	Clearance
Flat to 6/12	1 ft
6/12 to 7/12	1 ft 3 in.
7/12 to 8/12	1 ft 6 in.
8/12 to 9/12	2 ft
9/12 to 10/12	2 ft 6 in.
10/12 to 11/12	3 ft 3 in.
11/12 to 12/12	4 ft

Note: Vent caps should be 12 in. or less in diameter and 8 ft from vertical walls (see Figure 6-3).

- Through-wall venting for Category II and Category IV appliances or other condensing types of venting cannot terminate over other equipment that could be damaged by the condensation and cannot terminate over public walkways.
- Mechanical draft vents must be at least 7 ft above grade if located adjacent public walkways (also see Figures 6-9 and 6-10).
- Clearances for factory-built chimneys are as per the manufacturer's installation instructions.

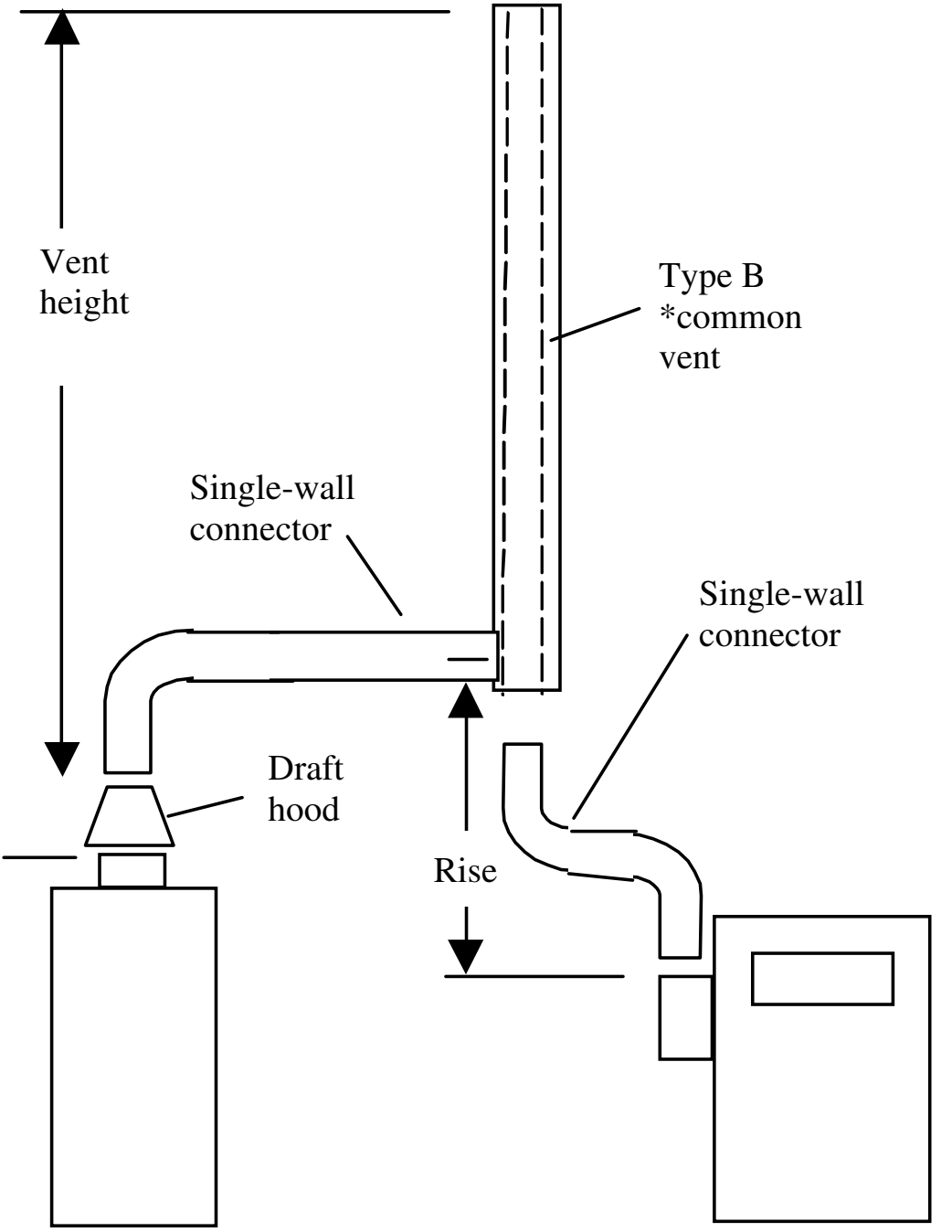


Figure 6-4 TYPICAL VENT AND CONNECTOR WITH TWO SINGLE-WALL CONNECTORS INTO TYPE B VENT

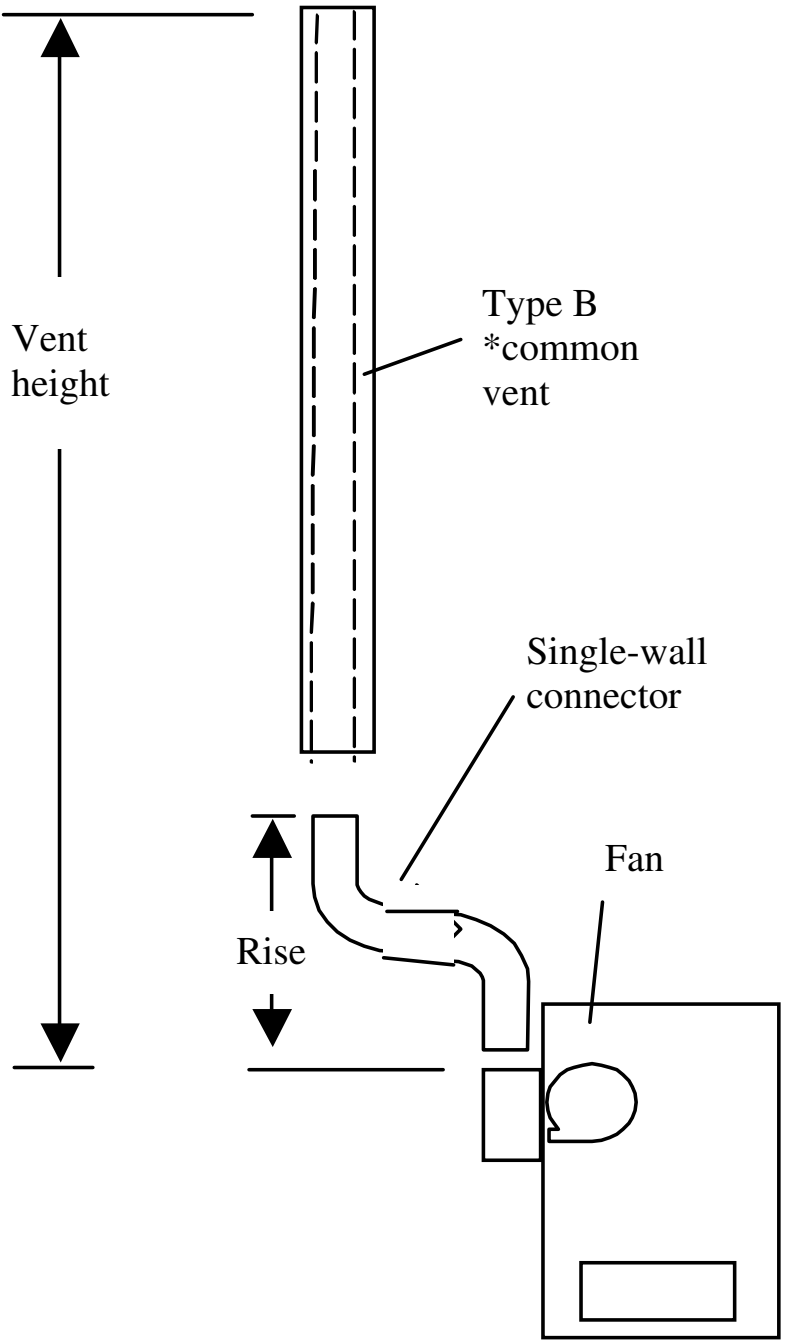


Figure 6-5 FAN-ASSISTED VENT WITH SINGLE-WALL CONNECTOR

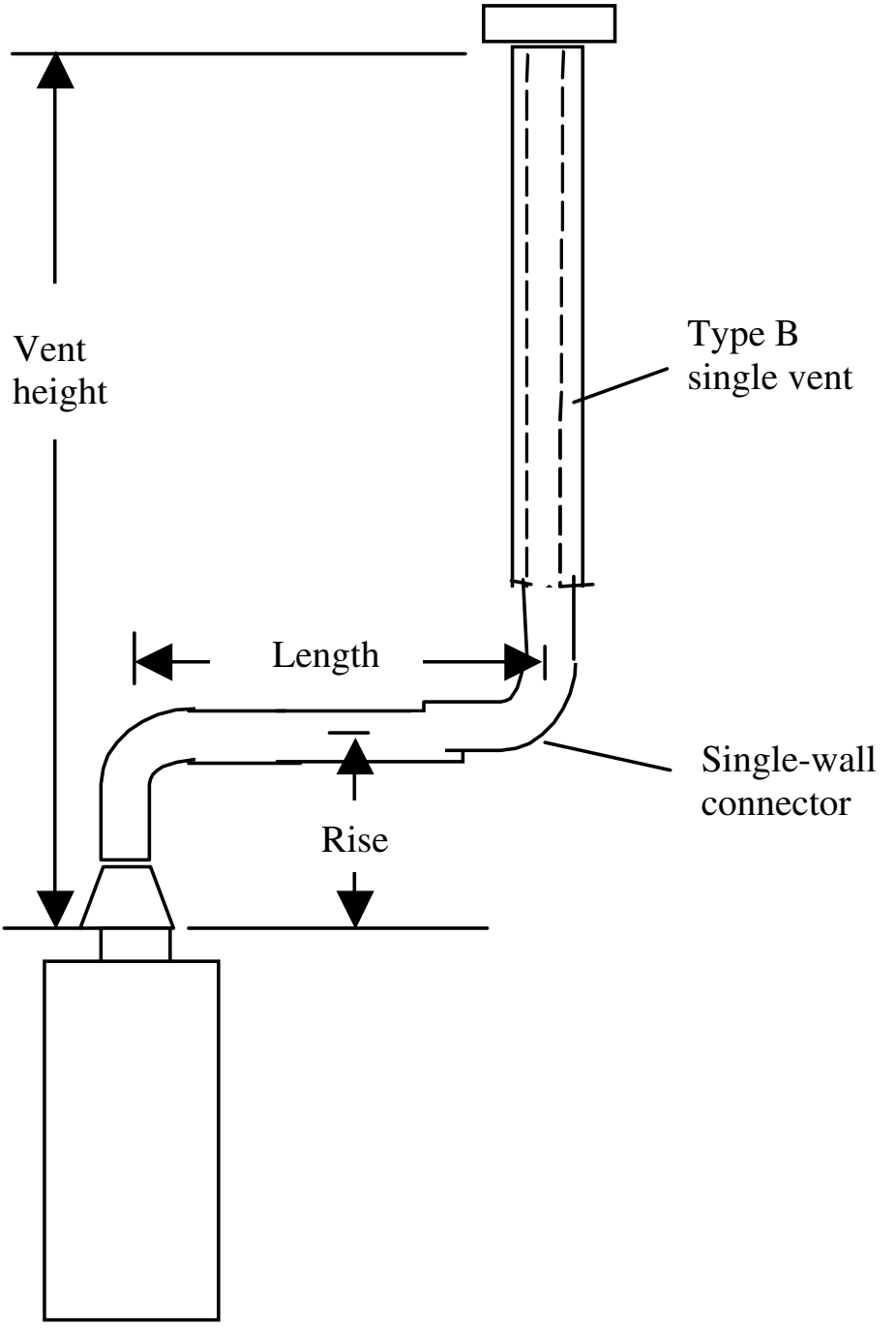


Figure 6-6 SINGLE APPLIANCE WITH SINGLE-WALL VENT CONNECTOR TO TYPE B VENT

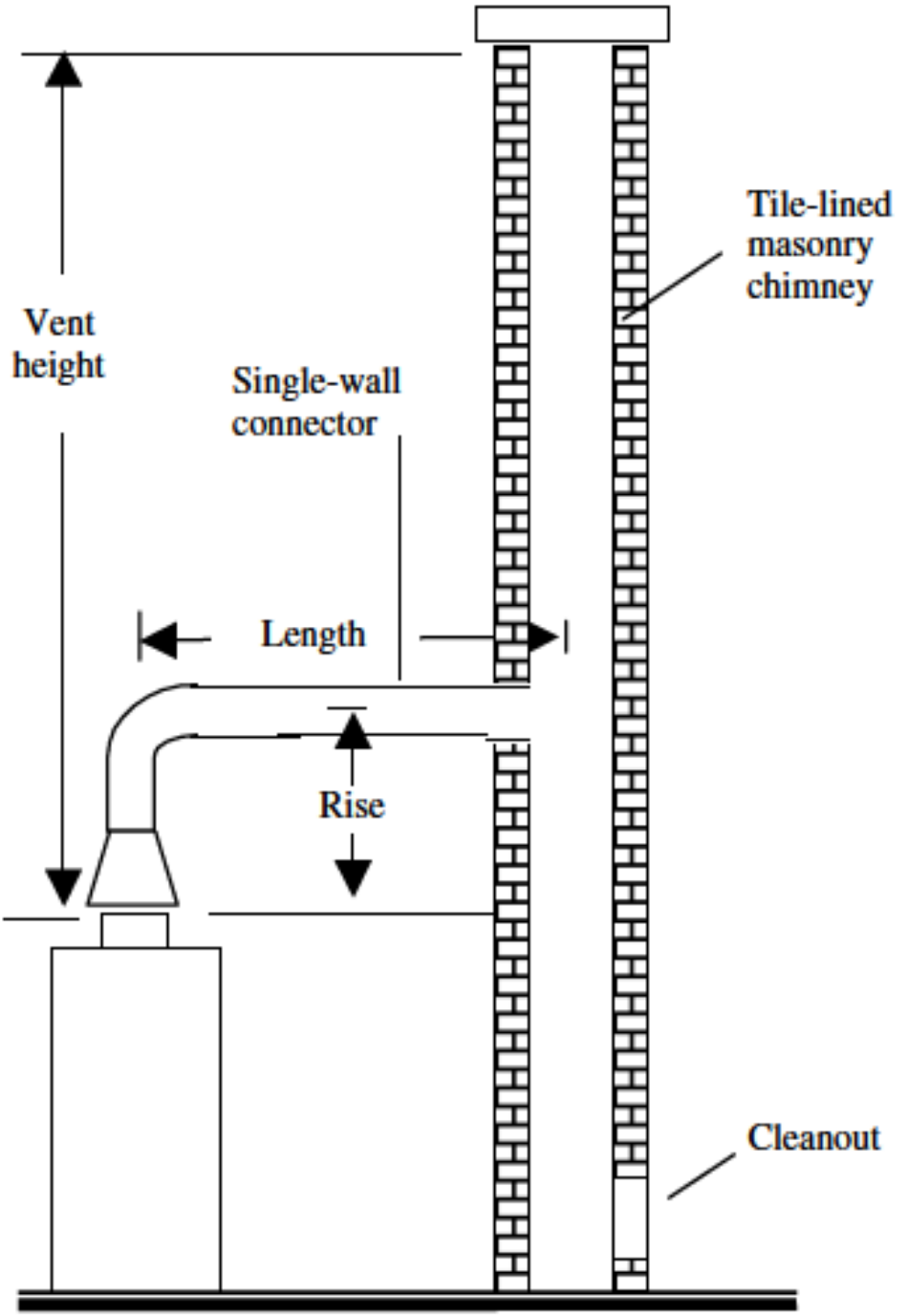
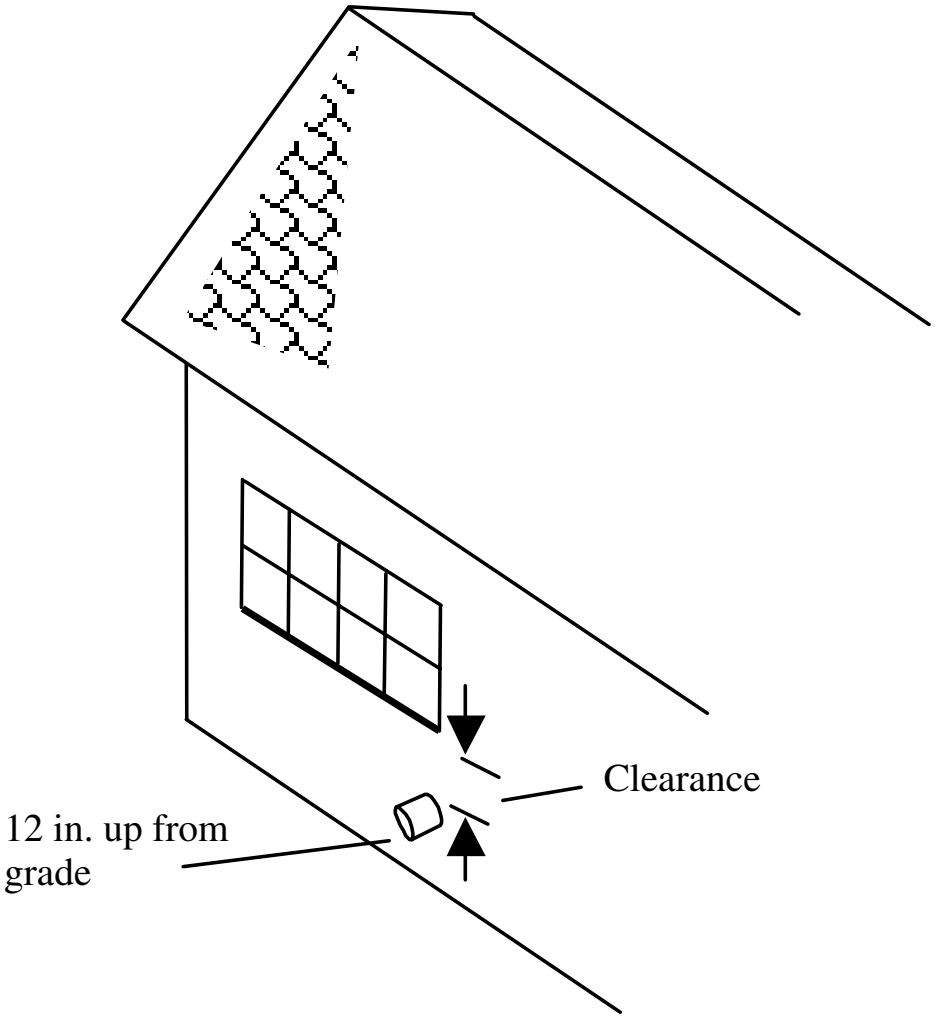


Figure 6-7 SINGLE-WALL CONNECTOR TO CHIMNEY



Input (Btu)	Clearance (in.)
<10,000	6
10,000–50,000	9
>50,000	12

Figure 6-8 CLEARANCE FOR DIRECT VENT APPLIANCES

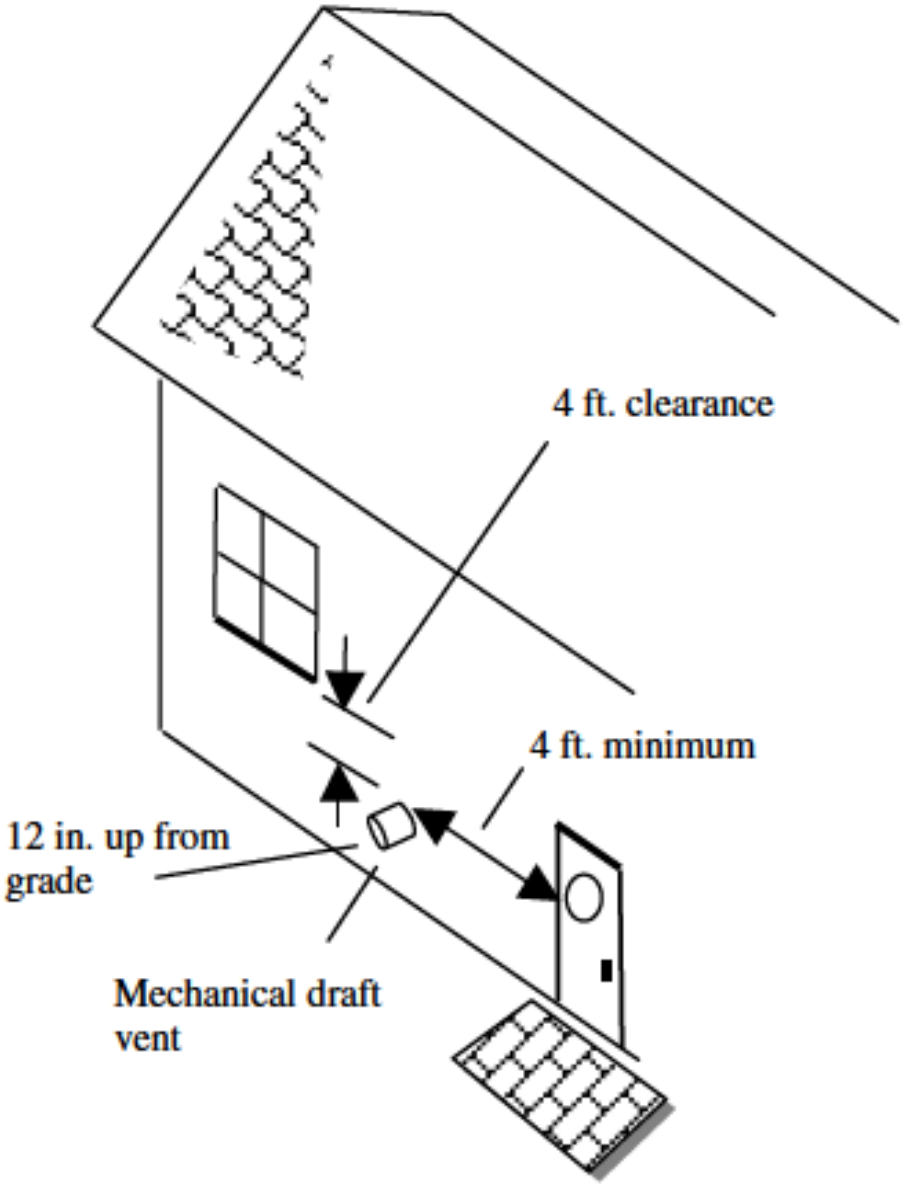


Figure 6-9 MECHANICAL DRAFT VENT LOCATIONS

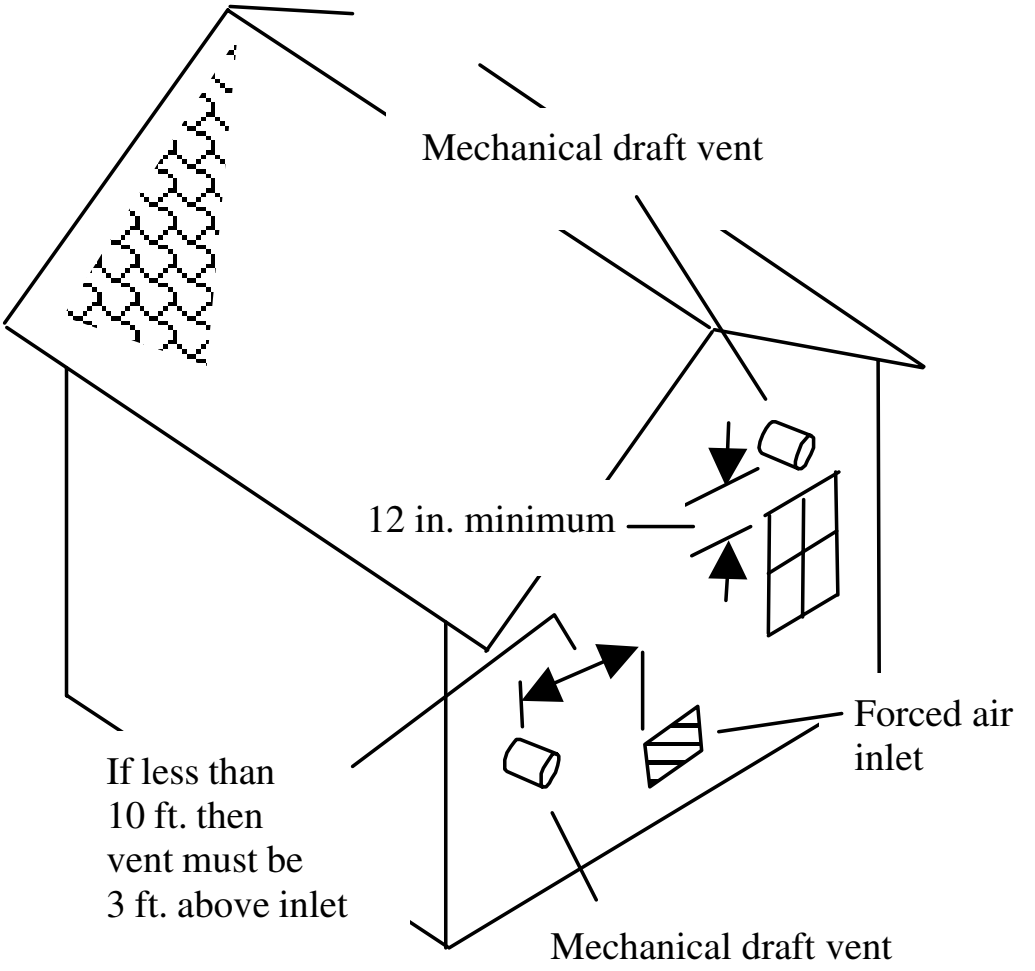


Figure 6-10 MECHANICAL DRAFT VENT LOCATIONS WITH FORCED AIR INLET

TABLE 6-8 CLEARANCES FROM COMBUSTIBLE MATERIALS FOR CONNECTORS FOR LISTED TYPE B VENT

Equipment	Clearance required
Equipment with draft hoods and those listed for use with Type B vents	As listed
Residential boilers, furnaces with listed gas conversion and draft hood	6 in.
Residential appliances listed for use with Type L vents	Not permitted
Unlisted residential appliances with a draft hood	Not permitted
Residential and low-heat equipment other than ones listed above	Not permitted

TABLE 6-9 CLEARANCES FROM COMBUSTIBLE MATERIALS FOR CONNECTORS FOR LISTED TYPE L VENT

Equipment	Clearance required
Equipment with draft hoods and those listed for use with Type B vents	As listed
Residential boilers, furnaces with listed gas conversion and draft hood	6 in.
Residential appliances listed for use with Type L vents	As listed
Unlisted residential appliances with a draft hood	6 in.
Residential and low-heat equipment other than ones listed above	9 in.

TABLE 6-10 CLEARANCES FROM COMBUSTIBLE MATERIALS FOR CONNECTORS FOR SINGLE-WALL METAL PIPE

Equipment	Clearance required
Equipment with draft hoods and those listed for use with Type B vents	6 in.
Residential boilers, furnaces with listed gas conversion and draft hood	9 in.
Residential appliances listed for use with Type L vents	9 in.
Unlisted residential appliances with a draft hood	9 in.
Residential and low-heat equipment other than ones listed above	18 in.

Masonry Chimneys

- Chimneys are to be lined with approved clay flue lining, a listed liner, or other approved material that will resist corrosion, erosion, and weakening from the vent gases at temperatures up to 1800°F.
- If liners are installed in existing chimney structures (Type B), then the connection must be marked not to allow any solid or liquid burning appliances to be attached.
- Chimneys are to extend at least 5 ft above the highest connected equipment draft hood outlet or flue collar.
- Sizing of chimneys is as follows:

(a) The effective area of a chimney serving listed appliances with draft hood. Category I appliance listed for use with Type B vents is to be sized using Figure 6-11 and Table 6-11.

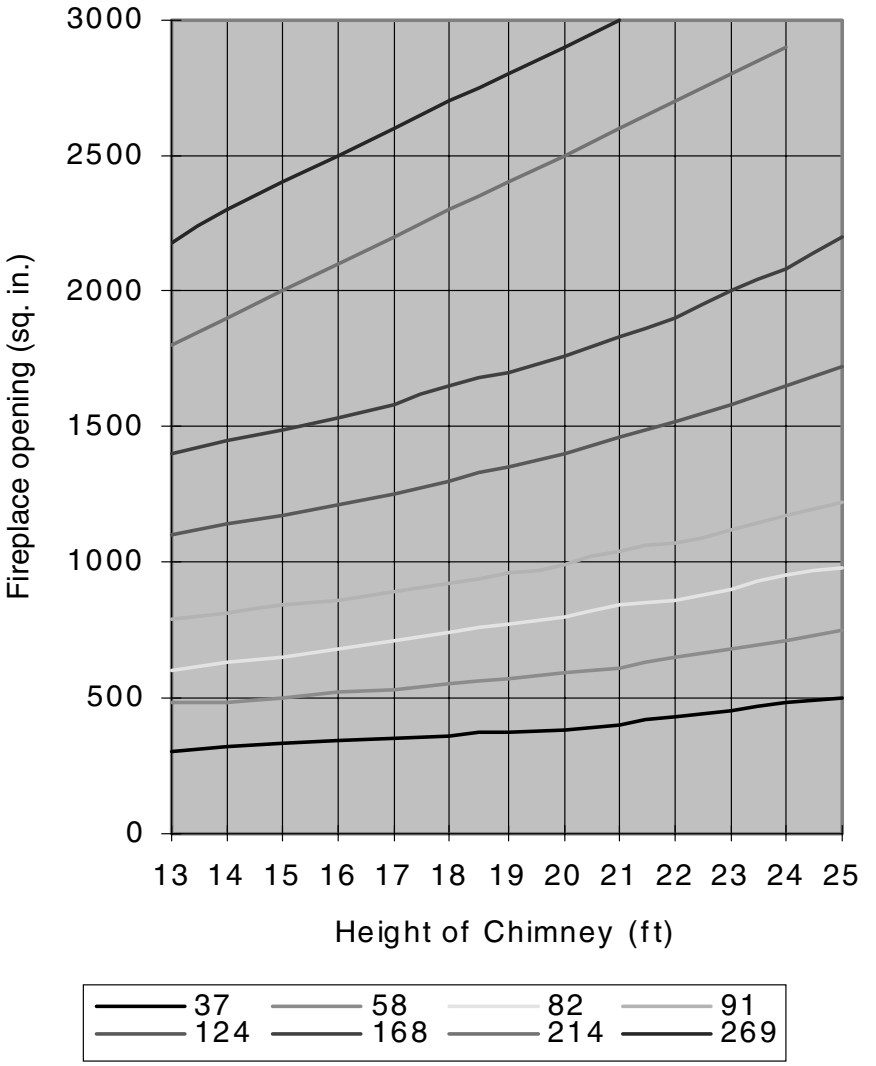


Figure 6-11 MINIMUM FLUE SIZES FOR MASONRY CHIMNEYS

TABLE 6-11 MASONRY CHIMNEY LINER DIMENSIONS WITH CIRCULAR EQUIVALENTS			
Nominal liner size (in.)	Inside liner dimensions (in.)	Circular equivalent (in.)	Square Inches
		4	12.2
4 × 8	2½ × 6½	5	19.6
		6	28.3
		7	38.3
8 × 8	6¾ × 6¾	7.4	42.7
		8	50.3
8 × 12	6½ × 10½	9	63.6
		10	78.5
12 × 12	9¾ × 9¾	10.4	83.3
		11	95
12 × 16	9½ × 13½	11.8	107.5
		12	113.0
		14	153.9
16 × 16	13¼ × 13¼	14.5	162.9
		15	176.7
16 × 20	13 × 17	16.2	206.1
		18	254.4
20 × 20	16¾ × 16¾	18.2	260.2
		20	314.1
20 × 24	16½ × 20½	20.1	314.2
		22	380.1
24 × 24	20¼ × 20¼	22.1	380.1
		24	452.3

(b) As an exception to using Table 6-8 for sizing for a single appliance with a draft hood, the vent connector and chimney flue should have an area not less than the appliance flue collar or draft hood and not greater than 7 times the draft hood outlet.

(c) When two appliances with draft hoods are connected then the flue area must be the same as the largest appliance outlet plus 50% of the smaller appliance outlet and not greater than 7 times the smaller draft hood outlet. For example,

Largest outlet + 50% of smallest < chimney flue size < 7 × the smallest outlet

- Chimneys previously used for liquid or solid fuels and now using fuel gas must have a cleanout (Figure 6-7). It is to be located so that its upper edge is 6 in. below the lowest edge of the lowest inlet opening.
- Offsets of Type B or Type L are not to exceed 45° from the vertical; however, any one angle is not to exceed 60°. The horizontal distance of a vent plus the connector vent must not exceed 75% of the vertical height of the vent.

Direct Venting

In direct vent installations, combustion air is drawn into a sealed firebox from outside the house through coaxial intake/exhaust pipe. This eliminates depressurization, resulting in a warmer, healthier environment. Direct venting also eliminates the need to extend the exhaust vent through the roof, making installation easier and less expensive.

WATER HEATERS

Refer to Table 6-12 for installation clearances and refer to Table 6-13 for residential hot water demands.

TABLE 6-12 CLEARANCES FOR WATER HEATERS

	Clearance (in.)			
Type	**Top**	**Front**	**Back**	**Sides**
Oil	6	6	36	36
Gas	6	18	36	36
Electric	6	6	36	48

- Fuel-burning water heaters must not be installed in a room used as a storage area.
- Gas and oil water heaters are prohibited in bedrooms, bathrooms, and clothes closets.
- Direct vent water heaters are not required to be installed within an enclosure.
- Full-bore type valves are allowed on the cold water supply side only!
- If installed in a garage the burner must be 18 in. above finish floor grade.

TABLE 6-13 REQUIRED SUPPLY FOR RESIDENTIAL HOT WATER HEATERS

	Demand (gallons)		
No. of baths	**Gas**	**Electric**	**Oil**
1 to 1½	30	40	30
2 to 2½	40	50	30
3 to 3½	50	66	30

Note: Based on 3 bedroom home.

BOILER/WATER HEATERS

Refer to Table 6-14 for expansion tank capacities for hot water systems.

TABLE 6-14 EXPANSION TANK MINIMUM CAPACITIES

System volume (gallons)	Diaphragm type	Non-pressurized type
10	1.0	1.5
20	1.5	3.0
30	2.5	4.5
40	3.0	6.0
50	4.0	7.5
60	5.0	9.0
70	6.0	10.5
80	6.5	12.0
90	7.5	13.5
100	8.0	15.0

Note: For a water temperature of 195°F, fill pressure of 12 psig, and minimum operating pressure of 30 psig.

THINK SAFETY AT ALL TIMES

CHAPTER 7
COMBUSTIBLE AIR

Combustible air systems are needed for water heaters/boilers or other fuel-burning equipment. These guidelines do not apply to direct vent appliances, listed and labeled appliances, and domestic clothes dryers.

- Buildings of unusually tight construction require combustible air from outside.
- Buildings of ordinary tightness require a volume of 50 cu ft per each 1000 Btu/hour input.
- Air requirements for other systems such as exhaust fans, fireplaces, and clothes dryers need to be factored in when computing the air space required.
- Openings for air in which louvers are used need to be adjusted for net free air passage as follows:

Metal louvers	75% of gross vent area
Wood louvers	25% of gross vent area

AIR FROM INSIDE BUILDING

Combustible air systems using all air from inside the building are diagrammed in Figures

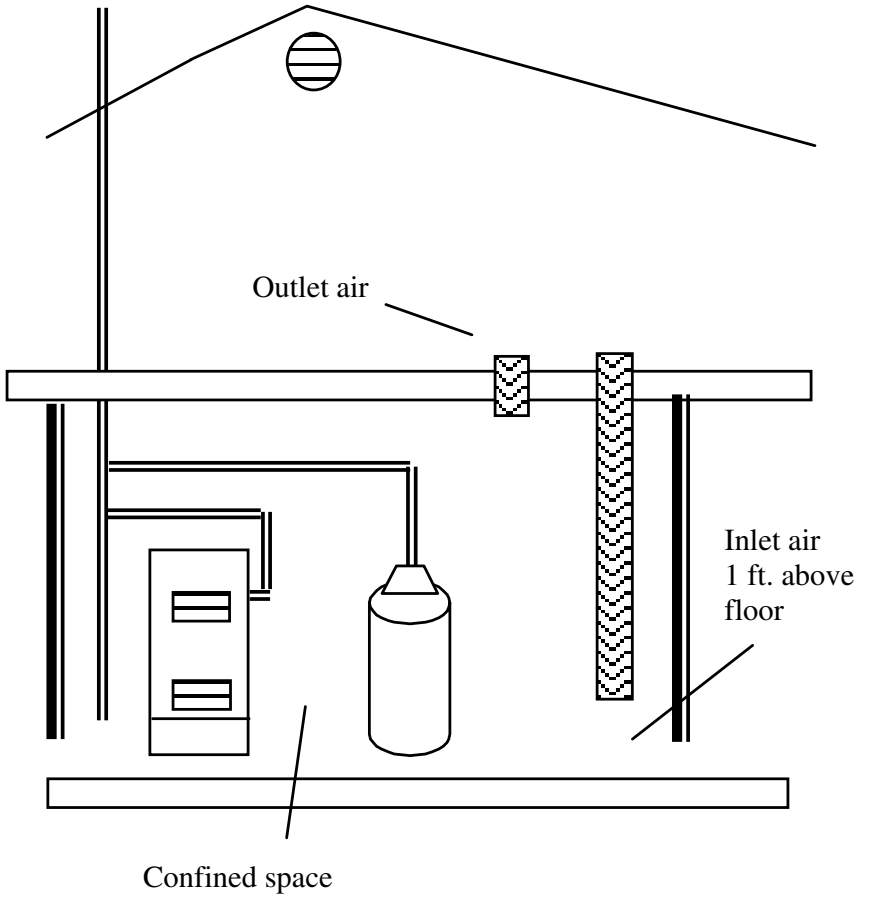


Figure 7-1 ALL AIR FROM BUILDING ATTIC (TWO OPENINGS)

7-1 and 7-2. Table 7-1 lists recommended opening sizes.

- Each inlet or outlet opening shall have 1 sq in. per 1000 Btu/hour, but not less than 100 sq in.
- If the confined area does not meet the 50 sq ft per 1000 Btu/hour requirement, then there must be two openings to adjacent

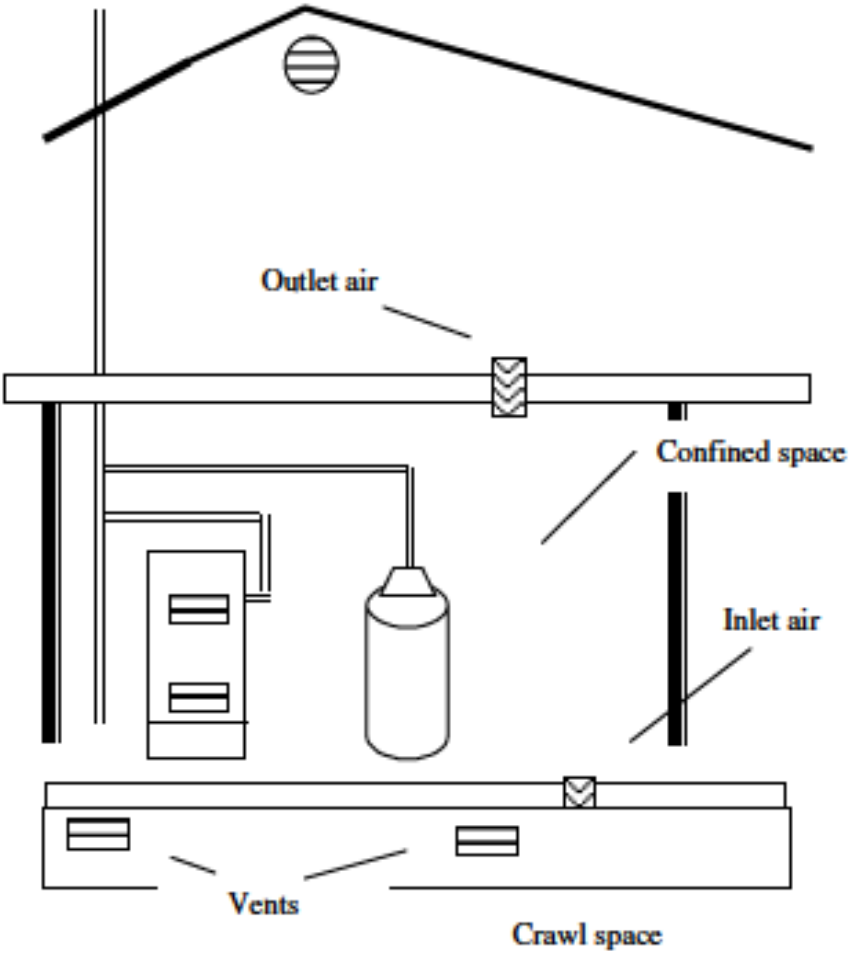


Figure 7-2 ALL AIR FROM BUILDING CRAWL SPACE AND VENTED INTO ATTIC (TWO OPENINGS)

areas: one 12 in. from the top of the space and one 12 in. from the bottom.

Checklist for All Air from Inside Building

- ❑ Ensure that a confined space has two openings.

TABLE 7-1 ALL AIR FROM INSIDE BUILDING (TWO OPENINGS)	
Input Btu per hour (all in the area)	1 sq in. per 1000 Btu each opening (sq. in.)
8,000	8
10,000	10
20,000	20
30,000	30
40,000	40
50,000	50
60,000	60
70,000	70
80,000	80
90,000	90
100,000	100
110,000	110
120,000	120
130,000	130
140,000	140
150,000	150
160,000	160
170,000	170
180,000	180
190,000	190

- ❏ Verify that each opening has a minimum free area of not less than 1 sq in. per 1000 Btu of the total gas input of all the units together but not less than 100 sq in.
- ❏ Check positions of openings: one 12 in. from the top and one 12 in. from the bottom are needed.
- ❏ Ensure that openings have a minimum dimension of 3 in.

AIR FROM OUTDOORS

Refer to Figure 7-3 and sizing recommendations in Tables 7-2 and 7-3 for combustible systems using all air from outdoors.

- Two openings are required: one 12 in. from the top of the enclosure and one 12 in. from the bottom.
- Openings can be connected to a crawl space or attic if those spaces are adequately ventilated.
- Vertical ducts must have as a minimum 1 sq in. per 4000 Btu/hour of all appliances in the space.
- Horizontal ducts must have as a minimum 1 sq in. per 2000 Btu/hour.
- Ducts in an attic must extend at least 6 in. above the ceiling joist and insulation.

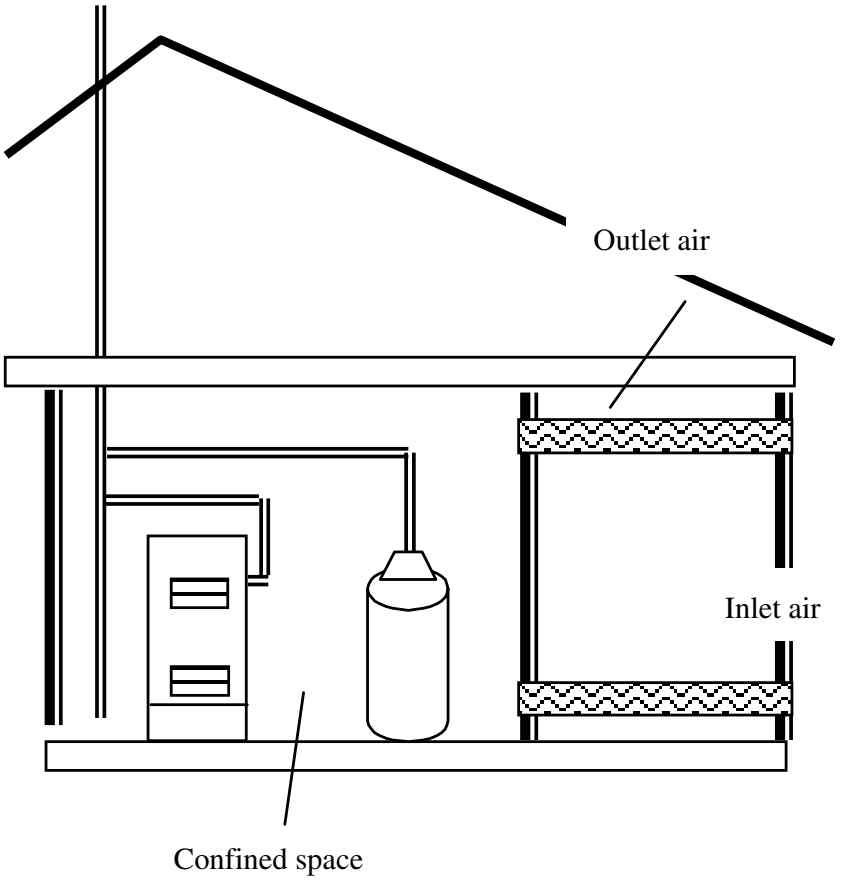


Figure 7-3 ALL AIR FROM OUTSIDE BUILDING

- Ducts in attic should not be screened.
- Ducts supplying combustible air from under floor areas require twice the required air opening.
- All outside openings require a corrosion-resistant screen with openings of at least ¼ in. and not larger than ½ in.

TABLE 7-2 ALL AIR FROM OUTSIDE BUILDING (TWO OPENINGS)	
Input Btu per hour (all in the area)	1 sq in. per 4000 Btu each opening (sq in.)
8,000	2
10,000	2.5
20,000	5
30,000	7.5
40,000	10
50,000	12.5
60,000	15
70,000	17.5
80,000	20
90,000	22.5
100,000	25
110,000	27.5
120,000	30
130,000	32.5
140,000	35
150,000	37.5
160,000	40
170,000	42.5
180,000	45
190,000	47.5

TABLE 7-3 ALL AIR FROM OUTSIDE BUILDING (TWO OPENINGS) FOR HORIZONTAL RUN DUCTS	
Input Btu per hour (all in the area)	1 sq in. per 2000 Btu each opening (sq. in.)
8,000	4
10,000	5
20,000	10
30,000	15
40,000	20
50,000	25
60,000	30
70,000	35
80,000	40
90,000	45
100,000	50
110,000	55
120,000	60
130,000	65
140,000	70
150,000	75
160,000	80
170,000	85
180,000	90
190,000	95

Checklist for All Air from Outdoors, Two-Opening Method

- ❑ Ensure that ducts are the same size as the opening.
- ❑ Ensure that openings have a minimum dimension of 3 in.
- ❑ Check positions of openings: one 12 in. from the top and one 12 in. from the bottom are needed.
- ❑ If a vertical duct is used, make sure 1 sq in. of free area is allowed for each 4000 Btu of all the units combined.
- ❑ If a horizontal duct is used, make sure the free opening is 1 sq in. per 2000 Btu of the total units in the space.

Checklist for All Air from Outdoors, One-Opening Method

- ❑ Ensure opening is 12 in. from the top of the enclosure.
- ❑ Check for 1 in. clearance from the sides and back.
- ❑ Check for 6 in. clearance from the front of the appliance.
- ❑ Verify that 1 sq in. per 3000 Btu of total input of all the units is allowed.

❑ Make sure the opening dimensions are not less than the sum of all the vent connections.

VENTILATION OPENINGS (CRAWL SPACES)

Ventilation openings shall be covered with any of the following materials, provided that the least dimension of the covering does not exceed ¼ in. (6 mm):

- Perforated sheet metal plates not less than 0.070 in. thick
- Expanded sheet metal plates not less than 0.047 in. thick
- Extruded load-bearing vents
- Cast-iron grills or gratings
- Hardware cloth of 0.035 in. (0.89 mm) wire or heavier
- Corrosion-resistant wire mesh, with the least dimension not exceeding ⅛ in. (3.2 mm)

CLOTHES DRYER (GAS) VENTING

❑ Ensure ducts are galvanized steel or aluminum if passing through any fire-rated assembly.

❑ Check that venting terminates outside and is not connected to any other vent assembly.

- ❏ Verify duct dimensions. Ducts cannot exceed 25 ft in length. Reduce by:
  - 2½ ft for each 45° bend
  - 5 ft for each 90° bend

  The duct must be a minimum of 4 in. in diameter.
- ❏ Check that joints are in the direction of flow.

THINK SAFETY AT ALL TIMES

CHAPTER 8
DRAINAGE LINES

Hubless cast-iron pipelines require support next to each joint. Hub type pipelines require support at 10-ft intervals and within 3 ft of each fitting.

- ❏ Check for required expansion joint at floors in plastic pipeline risers.
- ❏ Install cleanouts so they are flush with finish surfaces.
- ❏ Close each cleanout with a brass or PVC plug only.
- ❏ Check the elevation of each floor drain before the finished floor is placed to assure drainage slope.
- ❏ Check floor drain for type specified. The drain may require a special item such as a sediment basket, a backwater valve or a self-priming valve.
- ❏ On roof drains check for the clamping ring to hold the metal flashing and for the cast-iron strainer.
- ❏ Check for backup system. Interior roof drains or leaders require a backup system. Systems must have a minimum 1% slope.

HEATING PIPELINES

- ❏ Check for a slope of at least 1 in. in 10 ft.
- ❏ Check fitting types. Reducing fittings on horizontal lines must be the eccentric type with the bottom of pipelines flat for positive drainage flow.
- ❏ Check for proper branch line take off from the high-temperature pipeline supply and return. The take off should be from the upper half of pipeline, at a 45° angle in direction of flow.
- ❏ Check for special piping from the high-temperature waterline air vents to the funnel drain.

REFRIGERATION AND AIR-CONDITIONING PIPELINES

- ❏ Check joint specifications. Refrigerant steel pipeline joints should be welded.
- ❏ Ensure that refrigerant tubing of copper or steel have brazed joints.

THINK SAFETY AT ALL TIMES

CHAPTER 9
FIRE SPRINKLER PIPELINES

Refer to Tables 9-1 to 9-5 for specifications for fire sprinkler systems.

- ❏ Check the approved shop drawings for the fire sprinkler system layout and pipe sizes.
- ❏ Check for possible conflict between final sprinkler head location and user items, such as large equipment or high shelving, which restrict the flow coverage or cause damage to the system.
- ❏ Review Chapter 3 of the National Fire Protection Association Standard 13 for supports, hangers, slope, and drainage.
- ❏ Do not allow paint on sprinkler heads.
- ❏ Check heads for proper temperature rating indicated by color code or stamped numbers.
- ❏ Ensure that the outside connection, where required, is the size indicated and mates with a fire department hose.
- ❏ Check for required sprinklers in concealed spaces such as elevator shafts and under stairs.
- ❏ Check for special protection against freezing, corrosion, and earthquakes, and for sprinkler head clearance from heat sources.

TABLE 9-1 MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR TYPE IA AND IB CONSTRUCTION BUILDINGS

Fire area (sq ft)	Fire flow (gallons/minute) measured at 20 psi	Flow duration (hours)
0–22,700	1500	2
22,701–30,200	1750	
30,201–38,700	2000	
38,701–48,300	2250	
48,301–59,000	2500	
59,001–70,900	2750	
70,901–83,700	3000	3
83,701–97,700	3250	
97,701–112,700	3500	
112,701–128,700	3750	
128,701–145,900	4000	4
145,901–164,200	4250	
164,201–183,400	4500	
183,401–203,700	4750	
203,701–225,200	5000	
225,201–247,700	5250	
247,701–271,200	5500	
271,201–295,900	5750	
>295,901	6000	
—	6250	
—	6500	
—	6750	
—	7000	
—	7250	
—	7500	
—	7750	
—	8000	

TABLE 9-2 MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR TYPE IIA AND IIIA CONSTRUCTION BUILDINGS

Fire area (sq ft)	Fire flow (gallons/minute) measured at 20 psi	Flow duration (hours)
0–12,700	1500	2
12,701–17,000	1750	
17,001–21,800	2000	
21,801–24,200	2250	
24,201–33,200	2500	
33,201–39,700	2750	
39,701–47,100	3000	3
47,101–54,900	3250	
54,901–63,400	3500	
63,401–72,400	3750	
72,401–82,100	4000	4
82,101–92,400	4250	
92,401–103,100	4500	
103,101–114,600	4750	
114,601–126,700	5000	
126,701–139,400	5250	
139,401–152,600	5500	
152,601–166,500	5750	
>166,501	6000	
—	6250	
—	6500	
—	6750	
—	7000	
—	7250	
—	7500	
—	7750	
—	8000	

TABLE 9-3 MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR TYPE IV AND V-A CONSTRUCTION BUILDINGS

Fire area (sq ft)	Fire flow (gallons/minute) measured at 20 psi	Flow duration (hours)
0–8,200	1500	2
8,201–10,900	1750	
10,901–12,900	2000	
12,901–17,400	2250	
17,401–21,300	2500	
21,301–25,500	2750	
25,501–30,100	3000	3
30,101–35,200	3250	
35,201–40,600	3500	
40,601–46,400	3750	
46,401–52,500	4000	4
52,501–59,100	4250	
59,101–66,000	4500	
66,001–73,300	4750	
73,301–81,100	5000	
81,101–89,200	5250	
89,201–97,700	5500	
97,701–106,500	5750	
106,501–115,800	6000	
115,801–125,500	6250	
125,501–135,500	6500	
135,501–145,800	6750	
145,801–156,700	7000	
156,701–167,900	7250	
167,901–179,400	7500	
179,401–191,400	7750	
>191,401	8000	

TABLE 9-4 MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR TYPE IIB AND IIIB CONSTRUCTION BUILDINGS

Fire area (sq ft)	Fire flow (gallons/minute) measured at 20 psi	Flow duration (hours)
0–5,900	1500	2
5,901–7,900	1750	
7,901–9,800	2000	
9,801–12,600	2250	
12,601–15,400	2500	
15,401–18,400	2750	
18,401–21,800	3000	3
21,801–25,900	3250	
25,901–29,300	3500	
29,301–33,500	3750	
33,501–37,900	4000	4
37,901–42,700	4250	
42,701–47,700	4500	
47,701–53,000	4750	
53,001–58,600	5000	
58,601–65,400	5250	
65,401–70,600	5500	
70,601–77,000	5750	
77,001–83,700	6000	
83,701–90,600	6250	
90,601–97,900	6500	
97,901–106,800	6750	
106,801–113,200	7000	
113,201–121,300	7250	
121,301–129,600	7500	
129,601–138,300	7750	
>138,301	8000	

TABLE 9-5 MINIMUM REQUIRED FIRE FLOW AND FLOW DURATION FOR TYPE V-B CONSTRUCTION BUILDINGS

Fire area (sq ft)	Fire flow (gallons/minute) measured at 20 psi	Flow duration (hours)
0–3,600	1500	2
3,601–4,800	1750	
4,801–6,200	2000	
6,201–7,700	2250	
7,701–9,400	2500	
9,401–11,300	2750	
11,301–13,400	3000	3
13,401–15,600	3250	
15,601–18,000	3500	
18,001–20,600	3750	
20,601–23,300	4000	4
23,301–26,300	4250	
26,301–29,300	4500	
29,301–32,600	4750	
32,601–36,000	5000	
36,001–39,600	5250	
39,601–43,400	5500	
43,401–47,400	5750	
47,401–51,500	6000	
51,501–55,700	6250	
55,701–60,200	6500	
60,201–64,800	6750	
64,801–69,600	7000	
69,601–74,600	7250	
74,601–79,800	7500	
79,801–85,100	7750	
>85,101	8000	

- ❑ Check electric power and alarm for the following:
  - Electric power correction ahead of the main switch
  - Effective location of the local alarm
  - Alarm tie-in with fire department, if required

THINK SAFETY AT ALL TIMES

CHAPTER 10
TESTING PIPING

PREPARATION

Testing is the responsibility of the contractor unless stated as an owner responsibility in the specifications. Check with the supervisor for recommended presence of user personnel during testing of certain systems, such as sprinklers. The system or portion of the system will be prepared for testing by the contractor who installed the pipeline. The inspector will be responsible for verifying the extent of test, the method, and results which will be reported and filed.

The following items must be checked:

- ❑ Determine extent of test.
- ❑ Ensure that the pipeline is isolated at the limits of the test with valves closed and the plugs and caps tightly in place.
- ❑ Check that pipeline valves are open within the test area.
- ❑ Check that pipelines are adequately blocked and anchored for pressure tests. Pipelines should be in the permanent, fixed position before the test is permitted.

- ❑ Check that joints are exposed for the visual or soap test requirements.
- ❑ When testing pipeline to be concealed, verify that the extent of the test includes all of the affected pipeline.
- ❑ For a pressure test, make sure diaphrams or other internal parts of valves, regulations, etc., which may be damaged by the pressure, have been removed.
- ❑ Review the test method to be used.
- ❑ Inspect the test instruments and apparatus for proper type, calibration and operation.
- ❑ When flushing to clean the pipeline, check to determine that coils for heating, air-conditioning, and refrigerant lines are bypassed to prevent flushing water from passing through coils.

PERFORMING TESTS

Water Pipelines

Pneumatic or hydrostatic test shall be used.

- ❑ Check codes for the correct pressure and length of time for the test.
- ❑ Check ambient temperature at beginning and end of test period for temperature differential and the correction factor for the final gauge reading.

- ❑ For the hydrostatic test, verify that the tested segment was vented to ensure it was completely filled with water.

Fuel-Gas Pipelines

An air pressure test, similar to the waterline test, is usually made. Do not use oxygen to test fuel-gas pipelines. Refer to National Fire Protection Association (NFPA) Bulletin 565 test requirements for nitrous oxide and oxygen system test requirements.

- ❑ Check the gas system for leakage immediately when beginning the test using fuel gas.
- ❑ Make sure that an appropriate test gas is used. Approved gases include air, carbon dioxide (CO_2), and nitrogen (N_2). Do not use oxygen (O_2).
- ❑ Ensure the system withstands a pressure of 10 pounds not less than 15 minutes.
- ❑ Check integrity of welded joints. Welded pipes with pressures exceeding 14 in. water column require a test pressure of 60 psi for a minimum of 30 minutes.

Drainage Lines

- ❑ Check that the test stack is high enough to provide the 10-ft head for all of the tested line.

- ❑ Ensure the system is able to maintain 5 psi pressure for 15 minutes.
- ❑ Check each joint for leakage.
- ❑ Conduct the final testing with the smoke or peppermint test. All fixtures are to be attached.

Heating Pipelines

Hydrostatic pressure testing is required for heating pipelines.

- ❑ Check system pressure. Usually 45 psig for 4 hours is required for low-temperature waterlines.
- ❑ Test high-pressure waterlines at 1½ times design pressure.

Refrigeration and Air-Conditioning Pipelines

Pneumatic pressure test is used on refrigerant pipelines using dry nitrogen. Refrigerant pipelines also require an evacuation test.

- ❑ Check each joint with soap solution.
- ❑ Also, charge refrigerant pipelines with refrigerant gas and check joints for leaks with a halide torch.
- ❑ Perform an evacuation test for refrigerant pipelines. Check the specifications for details.

- ❑ Check the hydrostatic pressure test on water pipelines for use of appropriate pressure and time requirements.

Fire Sprinkler Pipelines

Refer to Chapter 1, NFPA 13, for specific test requirements.

- ❑ Assure that feeder piping has been flushed before testing.
- ❑ Check for approved testing procedures and adequate monitoring of the tests by qualified person.
- ❑ Check the adequacy of contractor's required material and test certificates to be submitted after completion of tests.
- ❑ Ensure that test blanks used in the system during testing are of the approved type. Each blank should be numbered and accounted for at activation of the system.

CLEANING

Pipelines constructed with properly stored and protected pipe should need very little cleaning.

- ❑ Check that ends of unfinished lines are closed during work stoppages.

- ❏ Check the specification for flushing requirements. Flushing may be required for all pipelines.
- ❏ Check cleaning of water pipelines. The completed potable water system must be sterilized by chlorinating. Specification may require a test.
- ❏ Ensure that heating pipelines are cleaned with a chemical solution after successful completion of the pressure tests. Check for proper solution, temperature, and time.
- ❏ Verify cleaning of sprinkler pipelines. Fire sprinkler systems must be flushed and disinfected after testing.

ADJUSTING

When beginning the operating phase each piping system must be closely inspected for necessary adjustment and proper operation.

- ❏ Adjust flow and flush valves.
- ❏ Check air cocks for leakage; clean and adjust as required.
- ❏ Ensure that condenser and chilled water pipelines are balanced after testing.
- ❏ Check for heating system approved balancing procedure. This must be performed by a qualified technician.

- ❏ Maintain a copy of all reports for your records.

OPERATION

Specifications require that user personnel be instructed in proper system operation.

- ❏ Record the attendees and retain a copy of the instructions given.
- ❏ Check the posted operating instructions. Ensure that posting requirements are met. Make sure they include the required diagrams.
- ❏ Ensure that pipelines are coded as required. If piping is prepainted, make sure markings are not on the hidden side.
- ❏ Check for required spare parts and OEM manuals.

THINK SAFETY AT ALL TIMES

CHAPTER 11
PLUMBING FIXTURES AND MATERIALS

INSPECTIONS

Ensure that all plumbing fixtures and materials have been submitted and approved prior to fabrication and installation. During subsequent inspections, check to see that contract requirements and all ADA requirements were complied with during installation. Perform follow-up inspections. Inspections will be made as the installation of the plumbing systems progresses throughout the facility under construction or renovation. Obtain and review manufacturers' installation information.

STORAGE AND HANDLING

- ❏ Ensure that all materials and equipment are handled carefully, are properly stored, and are protected to prevent damage.
- ❏ Reject damaged materials and equipment and mark them. Have them removed from the site as soon as possible.
- ❏ Inspect the plumbing fixtures on arrival at the job site for conformance with contract requirements. Require proper storage and

protection from damage before and after installation.

- ❏ Ensure that fixtures are installed in compliance with contract requirements and all ADA requirements are satisfied.

COORDINATION OF WORK

Check for interferences between electrical, mechanical, architectural, and structural features especially in toilets and baths, room walls, floors, door swings, hallway ceilings, and pipe chases.

INSTALLATION

- ❏ Review the total plumbing system and how it fits into the total job. Review where the specific items are to be installed. Prior to installing plumbing fixtures check to ensure that all testing of water supply lines, vents, and drains have been completed.
- ❏ Check size, spacing, elevation, and location of wall and floor stub outs to receive plumbing equipment. Do not allow plumbing fixtures to be stained, or supply lines to be undersized. Ensure that the stub outs are corrected as necessary prior to setting plumbing fixtures.

- ❏ Check the locations of all joists. See Chapter 13 for notching and cutting limitations.
- ❏ Check location and firmness of the installation of specified equipment supports, holders, and tie down flanges.
- ❏ Check setting or attaching of plumbing fixtures for required seals, traps, grouting, and caulking. Check each fixture for alignment, height, anchorage, and plumbness.
- ❏ Check for use of approved finish such as chrome plating on exposed piping, valves, escutcheons, cover plates, and drains.
- ❏ Check for surge arrestors on lines having quick closing valves.
- ❏ Check for positioning of access opening to allow maintenance of surge arrestors and operation of control and shutoff valves.
- ❏ Check for individual shutoff valves at each piece of plumbing equipment. Check drawings and specifications.
- ❏ Check for connection of hot water piping to the left-hand side of showers, lavatories, and sinks. Also make sure only cold water is provided to toilets and urinals.
- ❏ Check for specified trim, materials, screws, and bolts.

PROTECTION

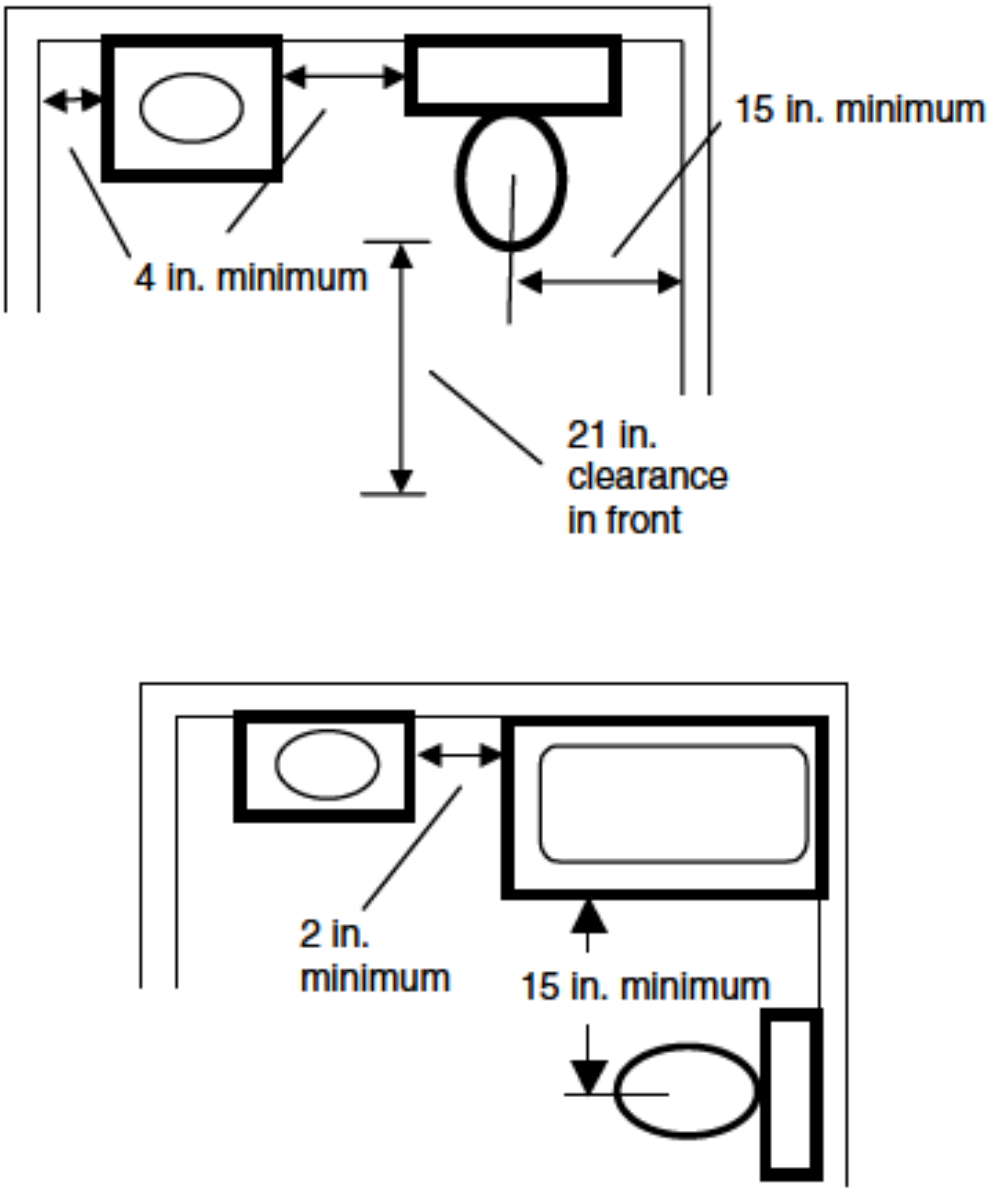
- ❏ Keep trash and debris out of fixtures and drains. Check fixtures for damage during installation. Make sure open ends are capped at the close of each day.
- ❏ Have the contractor cover and protect fixtures after installation to prevent future breakage, staining, or contractors' use.
- ❏ Check workmanship on all bolting, grouting, caulking, shimming, and leveling after the work in toilet and bath areas has been completed. All fixtures, whether wall or floor mounted, must be firmly attached.
- ❏ Check all ADA requirements for proper locations and required distances for all fixtures (see Figure 11-2).

CLEARANCES

Clearances for plumbing fixtures should follow code-approved recommendations (Figure 11-1).

PLUMBING FIXTURES

Plumbing fixtures should be installed according to the following guidelines. Refer to Table 11-1 for recommended flow rates and pressures.



Figures 11-1 MINIMUM FIXTURE CLEARANCES

TABLE 11-1 REQUIRED MINIMUM FLOW RATES AND PRESSURES FOR BATHROOM FIXTURES

Fixture	Flow Rate (gpm)	Pressure (psi)
Bathtub	4	8
Shower	3	8
Hose bibb	5	8
Sink	2.5	8

- All fixtures except water closet need strainers.
- Tail pieces for sinks, dishwashers, laundry tubs, and bathtubs must be at least 1½ in. OD.
- Fixtures with concealed tubular traps need an access panel 12 in. in its least dimension.
- Joints that are screwed, solvent-cemented, and fused or that withstand 25 psi do not need an access panel.
- No more than 8% lead content is allowed for water pipings/joints. Solder for water pipes must be <0.2% lead.
- Bolts and screws to mount fixtures need to be copper, brass, or other corrosion-resistant material.
- Joints must be water-tight at floors and walls.

- Water closets must not be less than 15 in. from walls or partitions.
- Energy codes require that all fixtures be caulked!

Showers

- Showers must have 900 sq in. of floor area.
- The fixture must deliver water at a rate of 2½ gpm at 80 psi.
- The water temperature must be set at 120°F or less.
- The fixture should have a clear radius of 30 in. on floor.
- The shower door must open outward!
- The shower riser must be secured to the structure.
- The shower head must be of an energy-conserving type with a maximum flow of 2½ gpm at 80 psi.
- The water supply requires a high limit stop of 120°F maximum.
- Floor drains must be at least 2 in. in diameter and have a strainer.

Water Closets

- The height of the seat should be 17 in. to 19 in. from the finish floor.
- The grab bar directly behind the water

closet should be set at a minimum height of 36 in.
- Flush controls may be hand operated or automatic. Controls should be mounted no more than 44 in. above the finish floor.

Toe Clearances

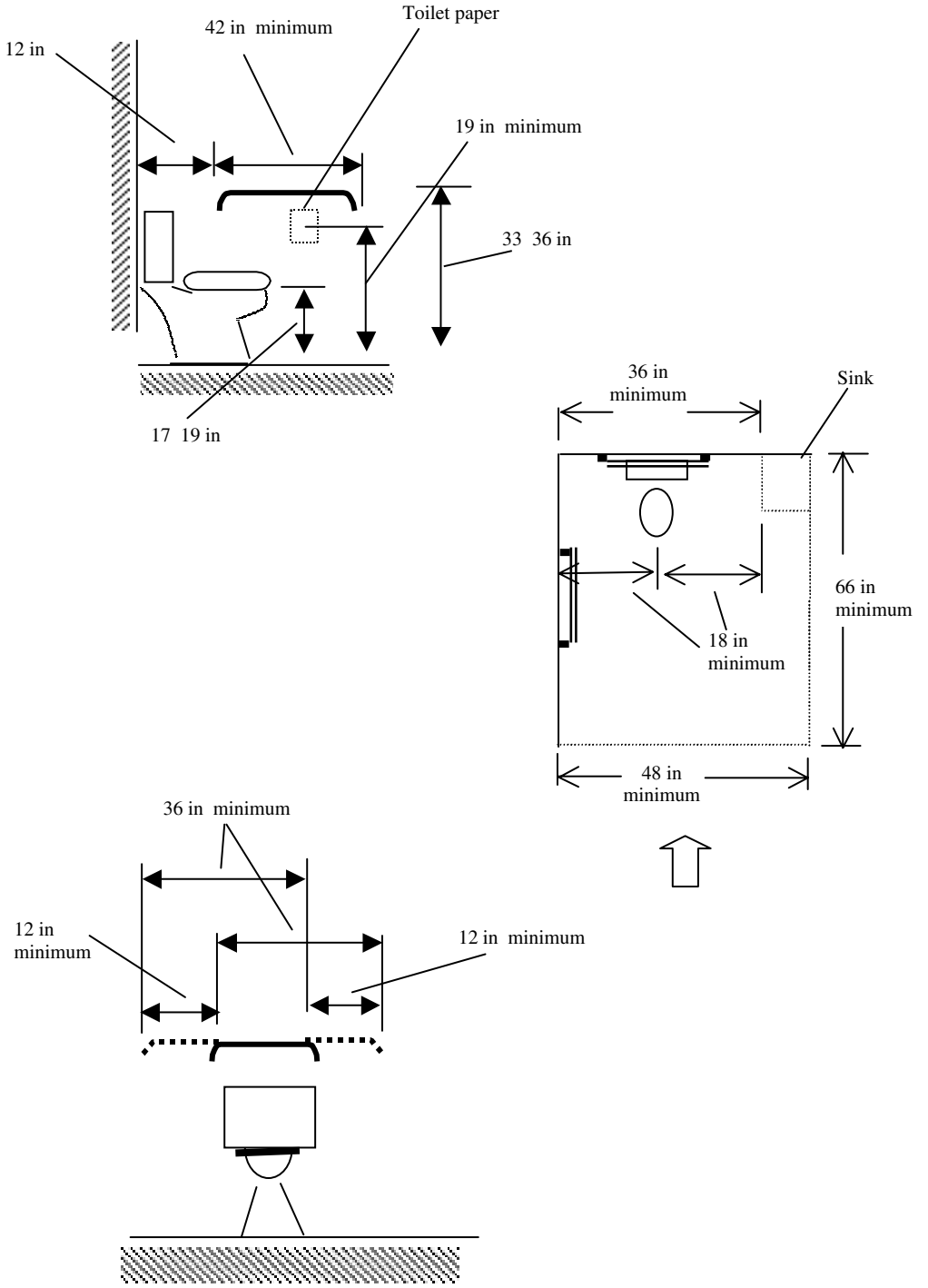
In a standard stall at least one of the side partitions and the front partition will have a minimum clearance of 9 in. Toe clearance may be omitted if the stall is greater than 60 in. in depth.

Lavatories

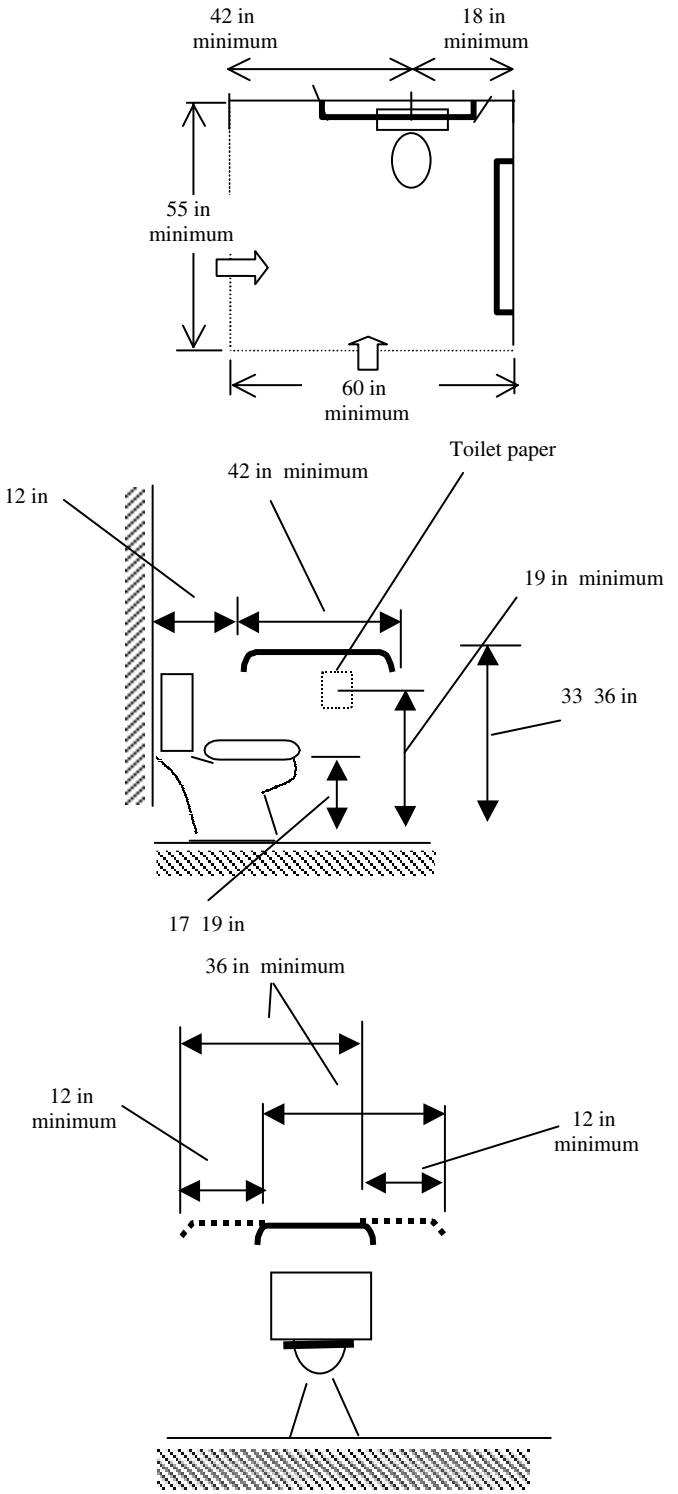
- The rim or counter surface cannot be located more than 34 in. from the finish floor.
- A minimum separation of 29 in. is required from the underside of the apron to the finish floor.
- Knee clearance (from wheelchair) is to be a minimum of 8 in. and toe clearance from the wall is to be a minimum of 6 in.

ADA FIXTURE REQUIREMENTS

Refer to Figure 11-2 for code-approved clearances for plumbing fixtures that are compliant with the Americans with Disabilities Act (ADA).



Figures 11-2 ADA FIXTURE REQUIREMENTS



Figures 11-2 *(continued)*

CHAPTER 12
PIPELINES, DRAINS, AND VENT STACKS

TRAPS AND VENTS

Drain traps should conform to approved dimensions (see Figures 12-1 and 12-2). Trap arm distances should be appropriate for the size of piping (see Table 12-1).

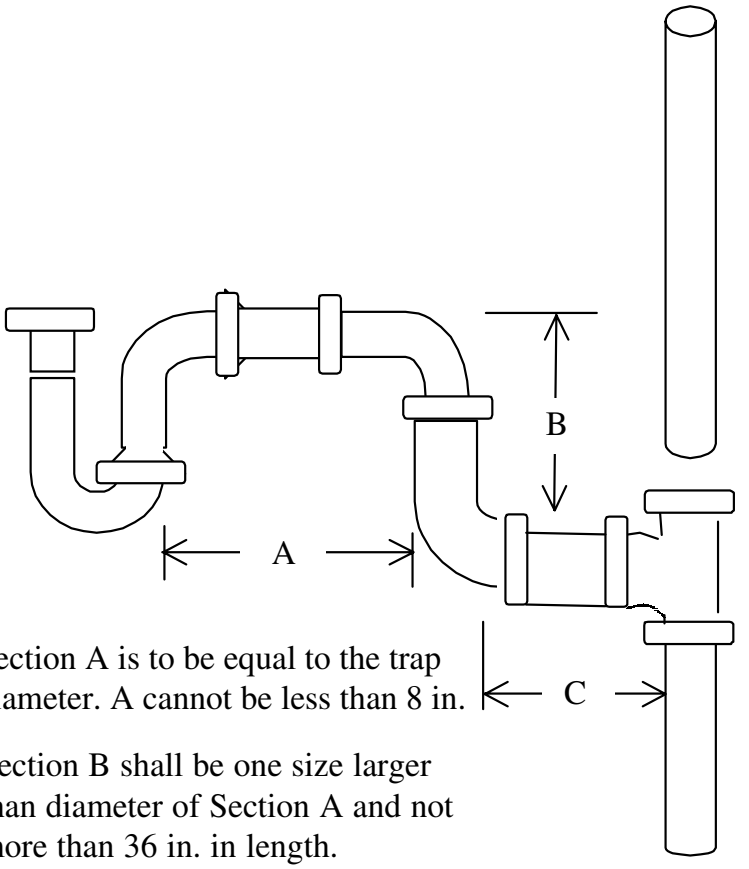
Venting slope and size requirements are given in Tables 12-2 to 12-6.

TABLE 12-1 MAXIMUM DISTANCES FOR TRAP ARMS

Size of trap (in.)	Slope (in./ft)	Distance from trap to vent (ft)
1¼	¼	5
1½	¼	6
2	¼	8
3	¼	12
4	⅛	16

CLEANING

- ❑ Inspect all surfaces for damage or stains. Replace or clean as necessary. Clean equipment before running water through it.
- ❑ See that all grease, paint, plaster, spackle,



- Section A is to be equal to the trap diameter. A cannot be less than 8 in.
- Section B shall be one size larger than diameter of Section A and not more than 36 in. in length.
- Section C diameter is to be one size larger than Section B.
- Bends are to be the diameter of the largest connection.

Figure 12-1 VERTICAL LEG FIXTURE

spots and debris are removed. See that anchorage and seals are firm. See that equipment is still undamaged. Accept only properly working, and undamaged equipment.

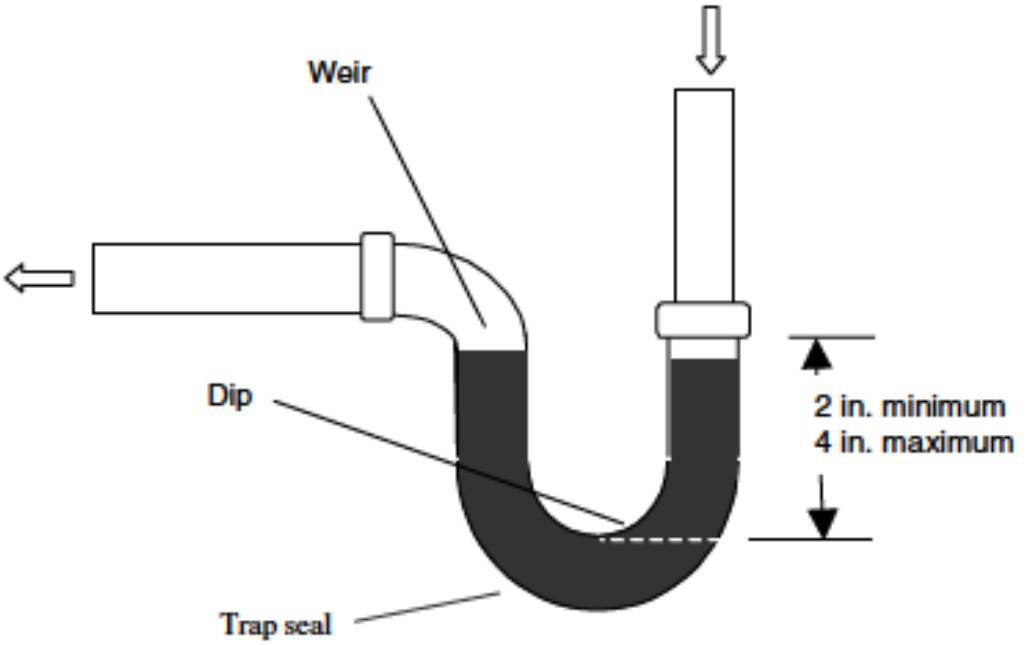


Figure 12-2 TRAP SEAL

ADJUSTING AND OPERATING

- ❑ Flush, turn on, or otherwise run water through the complete system. Check flow, water levels, quietness of operation, leakage, and shutoff capability. Repeat many times.
- ❑ Reject equipment that is damaged, does not properly operate, is not properly installed, and is not in new condition.

TABLE 12-2 VENTING SLOPES FOR HORIZONTAL BRANCHES

Vent type	Requirements
Fixture vents	See Table 12-3
Common vents	See Table 12-4
Wet vents	See Table 12-5
Waste stack vents	See Table 12-6
Circuit vents	Maximum 1 vertical unit in 12 (8%)
Combination waste and vent	Maximum ½ vertical unit in 12 (4%)
Island fixture vent	
Single vent	Rise vertically to above fixture before offsetting vertically or horizontally
Multiple vents	Extend a minimum of 6 in. above highest fixture before connecting to outside vent

TABLE 12-3 FIXTURE VENTS

Fixture trap (in.)	Slope (in. ft)	Distance from Trap (ft)
1¼	¼	5
1½	¼	6
2	¼	8
3	¼	12
4	⅛	16

TABLE 12-4 COMMON VENTS

Pipe size (in.)	Maximum discharge from upper fixture drain (d.f.u.)
1½	1
2	4
2½ to 3	6

TABLE 12-5 WET VENT SIZE

Pipe size (in.)	Fixture unit load (d.f.u.)
1½	1
2	4
2½	6
3	12
4	32

TABLE 12-6 WASTE VENT STACK SIZE

Stack size (in.)	*Maximum number of fixture units (d.f.u.)*	
	Total into one branch	Total discharge for stack
1½	1	2
2	2	4
2½	No limit	8
3	No limit	24
4	No limit	50

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CHAPTER 13
DRILLING AND NOTCHING STRUCTURAL WOOD MEMBERS

STUDS

Refer to Figure 13-1 and Tables 13-1 and 13-2.

Load-bearing studs may be drilled or notched as follows:

- Holes should be less than 40% of stud depth.
- Notches should be less than 25% of stud depth.

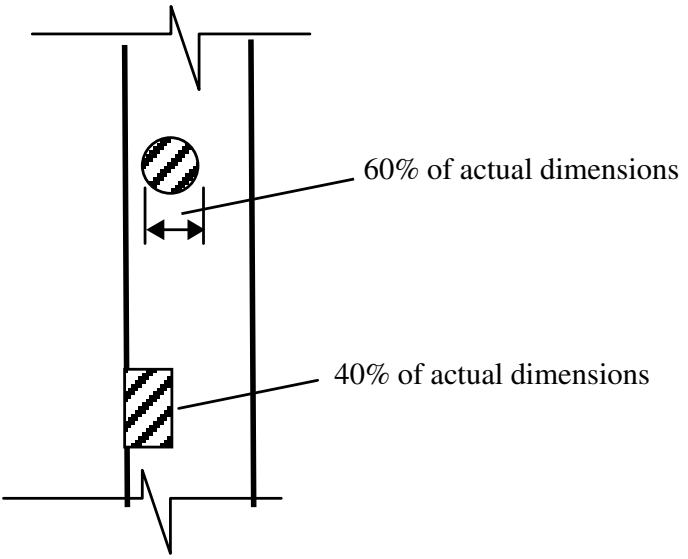


Figure 13-1 NOTCH AND HOLE MAXIMUMS IN LOAD-BEARING STUDS

TABLE 13-1 HOLE AND NOTCH MAXIMUMS IN LOAD-BEARING STUDS

Nominal (in.)	Actual (in.)	40% Holes (in.)	25% Notches (in.)
2 × 4	1½ × 3½	1 13/32	7/8
2 × 6	1½ × 5½	2 3/16	1 3/8

TABLE 13-2 HOLE AND NOTCH MAXIMUMS IN NON-LOAD-BEARING STUDS

Nominal (in.)	Actual (in.)	60% Holes (in.)	40% Notches (in.)
2 × 4	1½ × 3½	2 3/32	1 13/32
2 × 6	1½ × 5½	3 5/16	2 3/16

Non-load-bearing studs may be altered as follows:

- Holes must be less than 60% of stud depth.
- Notches must be less than 40% of stud depth.

JOISTS

Refer to Figures 13-2 and 13-3 and Tables 13-3 to 13-6.

- Notches must be less than ⅙ of joist depth.
- No notches or holes are allowed in middle third of joist!

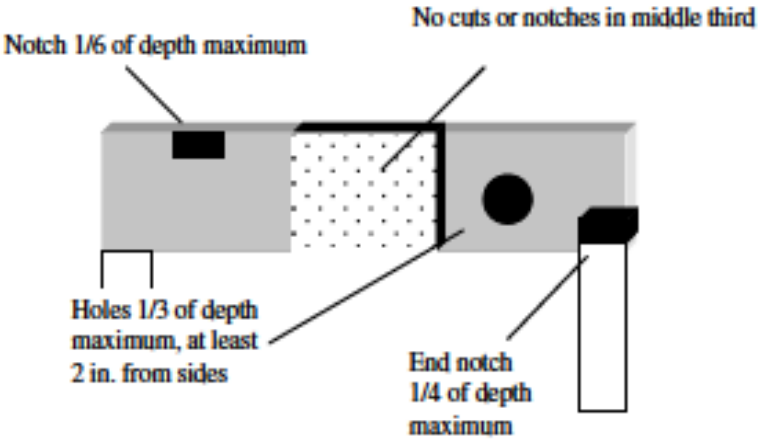


Figure 13-2 NOTCH AND HOLE SPACINGS AND SIZES ALLOWED FOR JOISTS

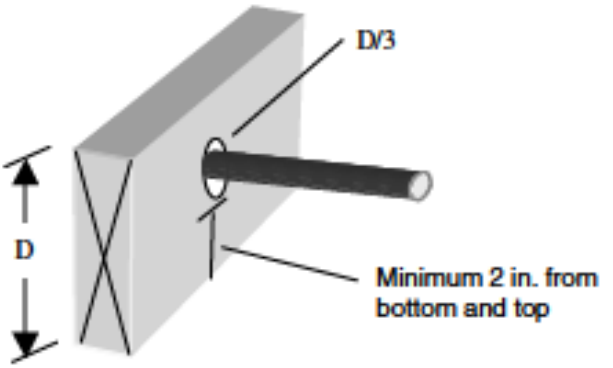


Figure 13-3 MAXIMUM HOLE DIAMETER AND LOCATIONS IN JOISTS

TABLE 13-3 DRILLED HOLE MAXIMUMS IN JOISTS		
Nominal (in.)	Actual (in.)	⅓ or 33% (in.)
2 × 6	1½ × 5¼	1¾
2 × 8	1½ × 7¼	2 13/32
2 × 10	1½ × 9¼	3 3/32
2 × 12	1½ × 11¼	3¾
2 × 14	1½ × 13¼	4¾

TABLE 13-4 NOTCH MAXIMUMS IN JOISTS		
Nominal (in.)	Actual (in.)	⅙ or 17% (in.)
2 × 6	1½ × 5¼	⅞
2 × 8	1½ × 7¼	1 7/32
2 × 10	1½ × 9¼	1 17/32
2 × 12	1½ × 11¼	1⅞
2 × 14	1½ × 14¼	2⅜

TABLE 13-5 NOTCH MAXIMUMS IN CEILING JOISTS OR RAFTERS		
Nominal (in.)	Actual (in.)	⅓ or 33% (in.)
2 × 6	1½ × 5¼	1¾
2 × 8	1½ × 7¼	2 13/32
2 × 10	1½ × 9¼	3 3/32
2 × 12	1½ × 11¼	3¾
2 × 14	1½ × 13¼	4¾

TABLE 13-6 END NOTCH MAXIMUMS IN CEILING JOISTS OR RAFTERS		
Nominal (in.)	Actual (in.)	¼ or 25% (in.)
2 × 6	1½ × 5¼	1 5/16
2 × 8	1½ × 7¼	1 13/16
2 × 10	1½ × 9¼	2 5/16
2 × 12	1½ × 11¼	2 13/16
2 × 14	1½ × 13¼	3 9/16

- No holes are allowed within 2 in. of top or bottom.
- Drilled holes must be less than ⅓ of joist depth.

METAL PLATE PROTECTION

Metal plate protection is required for plumbing passing through top plates (Figure 13-4) and for gas tubing passing through studs and joists (Figure 13-5).

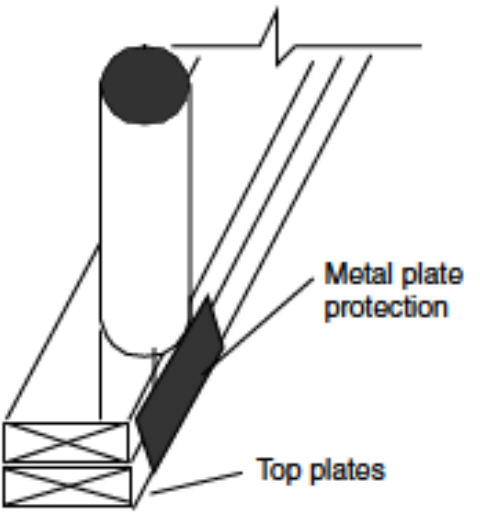


Figure 13-4 REQUIRED METAL PLATE PROTECTION FOR PLUMBING PASSING THROUGH TOP PLATES

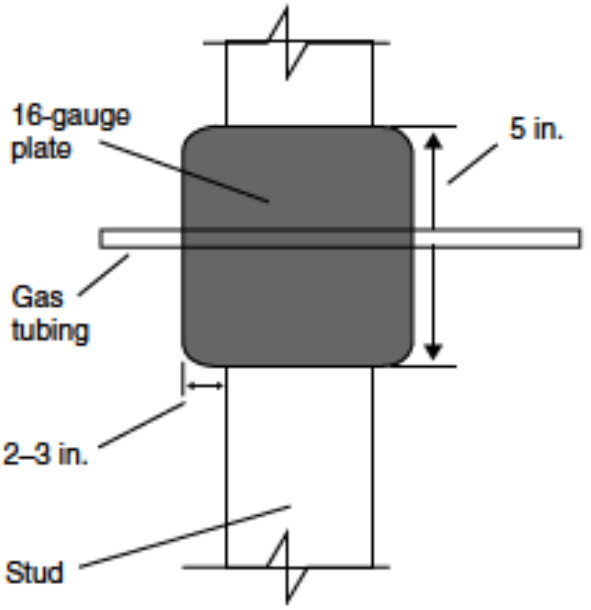


Figure 13-5 METAL PLATE REQUIREMENTS FOR GAS TUBING IN WOOD CONSTRUCTION

CHAPTER 14
WATER LINES

- Water lines should be tested 30 minutes at 100 psi using potable water only.
- The maximum run is 60 ft in residential systems.
- The minimum water line diameter is ¾ in.
- Piping must be rated at 160 psi at 73°F and should be approved for the intended use (see Table 14-1).
- Only ABS, PVC, or PE can be used for cold water piping.

TABLE 14-1 APPROVED PIPING

Acronym	Chemical name	Typical uses
ABS	Acrylonitrile butadiene styrene	Rigid, black, used for drain waste and vents
CPVC	Chlorinated polyvinyl chloride	Like PVC, also can be used for hot water
PB	Polybutylene	Used for water lines, both hot and cold
PE	Polyethylene	Flexible plastic tubing for cold water
PP	Polypropylene	Rigid plastic for traps and drain lines
PVC	Polyvinyl chloride	Rigid plastic used in cold water and DWV lines
SR	Styrene rubber	Rigid pipe for underground use

- Only CPVC, PB, or PE can be used for either hot or cold water.
- Water, soil, and waste piping must be protected from freezing.
- Water lines require a pressure-reducing valve if the pressure is over 80 psi.
- A minimum pressure of 40 psi is required, for wells also. Water lines should not be tested at less than the working pressure. If tested with air, use not less than 50 psi.
- Sizing of piping should be adequate for demand (see Table 14-2).

TABLE 14-2 MAXIMUM NUMBER OF FIXTURE UNITS ALLOWED TO BE CONNECTED TO BRANCHES AND STACKS

Pipe size (in.)	Horizontal branch	One vertical branch	Special conditions
1¼			Limited to a single fixture
1½	3	4	No water closets
2	6	10	
2½	12	20	No water closets
3	20 (maximum of 3 water closets)	48 (maximum of 6 water closets)	
4	160	240	

- Air gaps are required at the discharge point of a relief valve or piping. The minimum air gap is measured vertically from the lowest end of the water supply outlet to the flood rim or receptor.
- Soil, waste, and drains passing under a footing or through a foundation wall need to be placed in an iron pipe sleeve two sizes larger; or the wall must have a relieving arch.
- Piping should be adequately supported (refer to Table 14-3).

TABLE 14-3 PIPING SUPPORTS

Type	*Maximum spacing for*	
	Horizontal supports	**Vertical supports**
Cast iron	5 or 10 ft if 10-ft pipe is used	Each story not to excede 15 ft
Steel		
¾ in.	10 ft 0 in.	15 ft 0 in.
1 in.	12 ft 0 in.	15 ft 0 in.
Copper		
1¼ in.	6 ft 0 in.	10 ft 0 in.
1½ in.	10 ft	10 ft 0 in.
Plastic (DWV)	4 ft 0 in.	Each story and a midway guide
Plastic rigid	3 ft 0 in.	Each story and a midway guide

DETERMINING REQUIRED WATER SUPPLY AND PIPE SIZES

❑ Step 1. Obtain the daily static service pressure from the local water company or from the developer. This number requires adjustment for the following conditions.

- If the elevation of the highest water supply is higher than the water meter location (source of the determined water static pressure), then the pressure is to be reduced by 0.5 psi for each foot in height variance. If the meter is higher than the furthest source then add 0.5 psi per foot of difference.
- If a water pressure-reducing valve is installed then the static pressure is to be reduced by 80% or the set pressure downstream of the reducing valve, whichever is smaller.
- Deduct for water softeners, backflow preventers, water filters, or other special equipment as per the recommendations of the manufacturers of these devices.
- Deduct the pressure in excess of 8 psi for special fixtures, such as flushometer tanks for water closets or temperature-controlled showers. For example, if the fixture has a psi deduction of 10 psi you

would deduct 2 psi for the static pressure (10 psi minus 8 psi).

- ❏ Step 2. Using the resulting pressure from the adjustments above from the corresponding tables (see Tables 14-4 to 14-7).
- ❏ Step 3. Determine the maximum developed length from the supply source and the most remote fixture for both hot and cold. This number is then multiplied by 1.2 to make adjustments for pressure loss due to pipe fittings. Use this number to enter the table chosen from Step 2.
- ❏ Step 4. To determine the size of the water service pipe follow down the maximum development length column to a fixture unit equal to (or greater than) all the fixture units (use the combined column for both the hot and cold runs) calculated by using the table corresponding to the calculated water pressure. Read to the left for the required water service piping size and water meter.
- ❏ Step 5. To determine the size of each branch line (either hot or cold), start at the most remote water demand and work back along the line to the main distribution, adding up each fixture unit value from Table 14-8 for either the hot or the cold column. Using the appropriate table for water

pressure as in Step 4 above, identify the same or next smaller water meter size and read the column to the right labeled Distribution pipe for the correct size of the branch. At no time is the branch line required to be larger than the main distribution line established in Step 4 above. Repeat this step for the remaining branch lines. Note that piping for future fixtures, such as those for an unfinished basement, for example, must also be figured in to the total.

Refer to Tables 14-9 and 14-10 for flow specification for plumbing fixtures.

TABLE 14-4 MINIMUM SIZE OF PIPING BASED ON WATER SUPPLY FIXTURE UNITS (30 TO 39 PSI PRESSURE)

Service pipe (in.)	Distribution pipe (in.)	*Maximum developed length*				
		40	60	80	100	150
¾	½	2.5	2	1.5	1.5	1
¾	¾	9.5	7.5	6	5.5	4
¾	1	32	25	20	16.5	11
1	1	32	32	27	21	13.5
¾	1¼	32	32	32	32	30
1	1¼	80	80	70	61	45
1½	1¼	80	80	80	75	54
1	1½	87	87	87	87	84
1½	1½	151	151	151	151	117

TABLE 14-5 MINIMUM SIZE OF PIPING BASED ON WATER SUPPLY FIXTURE UNITS (40 TO 49 PSI PRESSURE)

Service pipe (in.)	Distribution pipe (in.)	*Maximum developed length*				
		40	60	80	100	150
¾	½	3	2.5	2	1.5	1.5
¾	¾	9.5	9.5	8.5	7	5.5
¾	1	32	32	32	26	18
1	1	32	32	32	32	21
¾	1¼	32	32	32	32	32
1	1¼	80	80	80	80	65
1½	1¼	80	80	80	80	75
1	1½	87	87	87	87	87
1½	1½	151	151	151	151	151

TABLE 14-6 MINIMUM SIZE OF PIPING BASED ON WATER SUPPLY FIXTURE UNITS (50 TO 60 PSI PRESSURE)

Service pipe (in.)	Distribution pipe (in.)	*Maximum developed length*				
		40	60	80	100	150
¾	½	3	3	2.5	2	1.5
¾	¾	9.5	9.5	9.5	8.5	6.5
¾	1	32	32	32	32	25
1	1	32	32	32	32	30
¾	1¼	32	32	32	32	32
1	1¼	80	80	80	80	80
1½	1¼	80	80	80	80	80
1	1½	87	87	87	87	87
1½	1½	151	151	151	151	151

TABLE 14-7 MINIMUM SIZE OF PIPING BASED ON WATER SUPPLY FIXTURE UNITS (OVER 60 PSI PRESSURE)

Service pipe (in.)	Distribution pipe (in.)	*Maximum developed length*				
		40	60	80	100	150
¾	½	3	3	3	2.5	2
¾	¾	9.5	9.5	9.5	9.5	7.5
¾	1	32	32	32	32	32
1	1	32	32	32	32	32
¾	1¼	32	32	32	32	32
1	1¼	80	80	80	80	80
1½	1¼	80	80	80	80	80
1	1½	87	87	87	87	87
1½	1½	151	151	151	151	151

Note: A pressure-reducing valve is required for static pressures exceeding 80 psi.

TABLE 14-8 WATER SUPPLY FIXTURE UNITS FOR PLUMBING FIXTURES

Fixture or group	*Water supply fixture units (w.s.f.u.)*		
	Hot	Cold	Combined
Bathtub	1.0	1.0	1.4
Clothes washer	1.0	1.0	1.4
Dishwasher	1.4	—	1.4
Hose bibb	—	2.5	2.5
Kitchen sink	1.0	1.0	1.4
Lavatory	0.5	0.5	0.7
Laundry tub	1.0	1.0	1.4
Shower stall	1.0	1.0	1.4
Water closet	—	2.2	2.2
Full bath group	1.5	2.7	3.6
Half bath group	0.5	2.5	2.6
Kitchen group (w/o garbage disposal)	1.9	1.0	2.5
Laundry group	1.8	1.8	2.5

TABLE 14-9 FIXTURE FLOW CAPACITIES AT POINT OF DISCHARGE

Fixture	Flow rate (gpm)	Flow pressure (psi)
Bidet	2	4
Water closet	1.6	15
Water closet, tank, one piece	6	20
Bathtub	4	8
Dishwasher	2.75	8
Laundry tub	4	8
Lavatory	2	8
Sink	2.5	8
Shower	3	20
Hose bibb	5	8

TABLE 14-10 MAXIMUM FLOW RATES FOR PLUMBING FIXTURES

Fixture	Max flow rate
Lavatory faucet	2.2 gpm at 60 psi
Shower head	2.5 gpm at 80 psi
Sink faucet	2.2 gpm at 60 psi
Water closet	1.6 gallons per flush

POTABLE WATER PROTECTIONS

Lines for potable water should be protected by an appropriate device (Table 14-11). All protections must be accessible.

TABLE 14-11 POTABLE WATER PROTECTIONS

Potable water outlet	Protection device
Flush tanks	Antisiphon ball cock
Sill cocks, hose bibbs	Atmospheric type vacuum breaker Pressure type vacuum breaker Permanent hose vacuum breaker
Boilers	Backflow preventer with intermediate atmospheric vent Reduced pressure principle backflow (if chemically treated)
Heat exchangers	Air gap Double-wall construction
Lawn irrigation	Atmospheric type vacuum breaker Pressure type vacuum breaker Reduced pressure principle backflow
Fire sprinkler	Double check valve preventer Reduced pressure principle backflow preventer
Solar system	Intermediate atmospheric vent Reduced pressure principle backflow preventer

WATER PIPE CORROSION

Plumbing systems act very much like a battery. The metal piping acts as the anode while water is the oxygen-carrying solution. In a reaction the water and pipe try to reach equilibrium. In doing so the metal ions from the pipe go into the water. Thus oxidation occurs, which is commonly known as corrosion or rust. Metals corrode at different rates. Copper corrodes very slowly and makes an excellent supply vessel for water. Magnesium, zinc, and iron corrode faster.

Galvanizing of pipe is the process of coating the iron pipe with zinc, where the zinc will enter the water first before the iron and thus prolonging the decay or corrosion of the iron.

Other causes of pipe corrosion are as follows:

- Stray electric current
- Bacteria in the water supply
- Highly acidic water
- Contact between dissimilar metals

THINK SAFETY AT ALL TIMES

CHAPTER 15
SANITARY DRAINAGE

MATERIALS

Refer to Table 15-1 for code-approved materials for sanitary drainage systems.

TABLE 15-1 CODE-APPROVED MATERIALS

Material	Standard
Welded and seamless steel pipe (black or galvanized)	ASTM A 53
Cast-iron soil pipe and fittings (hub and spigot)	ASTM A 74
Cast-iron fittings (threaded)	ASTM A 126
Malleable iron fittings (threaded)	ASTM A 197
Seamless copper pipe	ASTM B 42
Seamless red brass pipe	ASTM B 43
Seamless copper tubing	ASTM B 75
Seamless copper water tubing (Types K, L, M)	ASTM B 88
ABS-DWV pipe and fittings	ASTM D 2661
PVC-DWV pipe and fittings	ASTM D 2665
3.25-in.-OD PVC-DWV pipe and fittings	ASTM D 2949
ABS-DWV schedule 40 with cellular core	ASTM F 628
Coextruded PVC plastic pipe with cellular core	ASTM F 891

(continued)

TABLE 15-1 *(CONTINUED)*

Material	Standard
Coextended composite ABS-DWV pipe and fittings	ASTM F 1488
Cast-iron soil pipe and fittings (hubless)	CISPI 301
Copper drainage tube (DWV) Mechanical couplings Solvent cement for ABS-DWV pipe and fittings	ASTM B 306 CSA B602M ASTM D 2235
Solvent cement for PVC-DWV pipe and fittings	ASTM D 2564
Socket bell for PVC-DWV pipe and fittings	ASTM D 2672
Primers for solvents	ASTM F 656
Hubless cast-iron soil pipe and fittings	ASTM A 888
Couplings used with hubless	CISPI 310-95
Shielded couplings	ASTM C 1277
Coextruded composite ABS-DWV schedule 40 IPS pipe solvent cement fittings	ASTM F 1488 ASTM D 2235 ASTM D 2661 ASTM F 628
Coextruded composite PVC-DWV schedule 40 IPS pipe solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891
Coextruded composite PVC-DWV IPS pipe, DR-PS140 PS200 solvent cement fittings	ASTM F 1488 ASTM D 2564 ASTM D 2665 ASTM F 891

DETERMINING DRAINAGE CAPACITY

- ❏ Step 1. Starting with the most remote fixture, add up all the fixture units downstream to the building drain. Refer to Table 15-2.
- ❏ Step 2. With the total fixture value from Step 1, use Tables 15-3 and 15-4 for sizing branches and stacks. Determine the fixture units for the branch in question using Tables 15-2 and 15-3.
- ❏ Step 3. Use Table 15-4 to determine the pipe diameter and slope for the building sewer or drain.

Refer also to Table 15-5 for recommended pipe sizing for a two-family dwelling. The following points should be kept in mind:

- Below-grade drain piping cannot be less than 1½ in. in diameter.
- Drain stacks may not be smaller than the largest horizontal branch. (Code allows for exceptions.)

TABLE 15-2 DRAINAGE FIXTURE UNITS	
Fixture type or group	**Drainage units**
Bar sink	1
Bathtub	2
Bidet	1
Clothes washer	2
Dishwasher	2
Floor drain	If used as receptor, use value of fixture discharging into it
Kitchen sink	2
Lavatory	1
Laundry tub	2
Shower stall	2
Water closet (1.6 gallons)	3
Water closet (>1.6 gallons)	4
Full bath	5
Full bath (with >1.6-gallon water closet)	6
Half bath	4
Half bath (with >1.6 gallon water closet)	5
Kitchen	3
Laundry	3
1.5 Baths	7
2 Baths	8
2.5 Baths	9
3 Baths	10
3.5 Baths	11

TABLE 15-3 MAXIMUM FIXTURE UNITS CONNECTED TO BRANCHES AND STACKS

Nominal pipe size (in.)	Horizontal branch	Any one vertical branch or drain
1¼ (note a)	—	—
1½ (note b)	3	4
2	6	10
2½ (note b)	12	20
3	20	48
4	160	240

Note a: 1¼ in. pipe is limited to a single fixture drain or trap arm.

Note b: No water closets.

TABLE 15-4 MAXIMUM FIXTURE UNITS ALLOWED TO BUILDING DRAIN, SEWER, OR BUILDING DRAIN BRANCH

Pipe diameter (in.)	*Slope per foot*		
	⅛ in.	¼ in.	½ in.
1½ (notes a, b)	—	— (note a)	— (note a)
2 (note b)	—	21	27
2½ (note b)	—	24	31
3	36	42	50
4	180	218	250

Note a: Limited to branch not serving more than two fixtures, one if serving a pumped discharge or garbage disposal.

Note b: No water closets.

TABLE 15-5 RECOMMENDED SIZING OF SANITARY DRAINAGE SYSTEMS

Fixture	*Pipe size (in.)*		
	Supply	Drain or trap	Vent
Main	1	N/A	N/A
House service	¾	N/A	N/A
Supply risers	¾	N/A	N/A
House sewer	N/A	4	N/A
House drain	N/A	3	N/A
Soil stack	N/A	3	N/A
Branch drain or vent	N/A	1½	1¼
Water closet	½	3½	2
Bathtub	½	1½	1¼
Lavatory	½	1½	2¼
Kitchen sink	½	1½	1¼
Clothes washer	½	2	1¼
Dishwasher	½	1½	1¼
Shower	½	2	1¼

Note: Based on two-family dwelling. N/A, Not applicable.

CLEANOUTS

- Cleanouts should be installed at not more than 100-ft intervals.
- Cleanouts should be installed at each change of direction exceeding 45°, but not

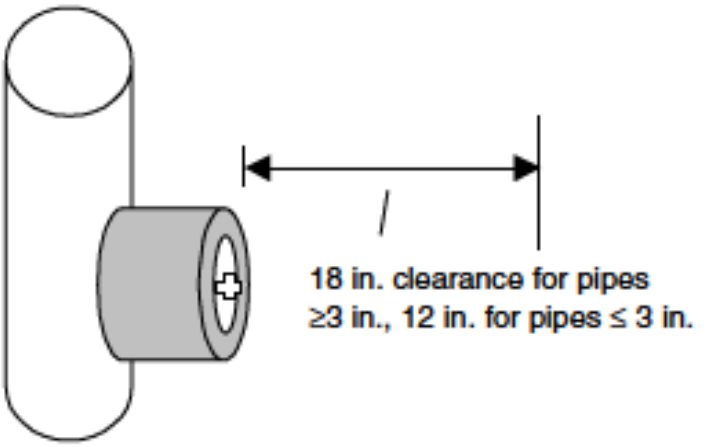


Figure 15-1 CLEANOUT CLEARANCES

more than one cleanout is required in each 40 ft regardless of the changes in direction.

- Cleanouts are to have a minimum front clearance of 18 in. for pipes 3 in. or larger. Pipes less than 3 in. must have 12 in. of clearance. Refer to Figure 15-1.
- The size of cleanouts should increase with pipe diameter (see Table 15-6).

TABLE 15-6 SIZING OF CLEANOUTS

Pipe size (in.)	Cleanout size (in.)
1½	1½
2	1½
3	2½
≥4	3½

FITTINGS

Drainage fittings are to be designed to maintain a slope of ¼ vertical unit to each horizontal unit.

TRAPS

- Slip joints may be used in drainage piping on both sides of the trap and in the trap seal.
- Trap arm lengths should be appropriate for the pipe diameter. Refer to Table 15-7.

TABLE 15-7 SIZING OF TRAP ARM LENGTHS

Diameter (in.)	Length (in.)
1¼	5
1½	6
2	8
3	12
4	16

DRAINS

- Drains 3 in. in diameter or less must have at least a 2% slope or ¼ vertical unit for each 12 horizontal units.

- Drains 4 in. in diameter or more must have at least a 1% slope or ⅛ vertical unit for each 12 horizontal units.

ROOF VENTS

- Roof vents penetrate through the roof a min of 6 in. (on the high side).
- Roof vents must vent downward if set through a wall or building overhang.

THINK SAFETY AT ALL TIMES

CHAPTER 16
SEPTIC TANKS

Refer to Tables 16-1 and 16-2 for sizing and placement of septic systems.

Note: In most areas in the United States the local health department is responsible for approving private septic systems. Check with them for requirements and specifications.

TABLE 16-1 CAPACITY REQUIREMENTS FOR RESIDENTIAL SEPTIC TANKS

Number of bedrooms	Tank capacity (gallons)
1 OR 2	750
3	1000
4	1200
5 OR 6	1500

TABLE 16-2 SEPARATION REQUIREMENTS FOR SEPTIC SYSTEMS

Item	*Minimum horizontal clearance (ft)*	
	Septic tank	Disposal fields
Buildings	5	8
Property line	5	5
Water well	50	50
Streams	50	50
Large trees	10	Not allowed
Water line	5	5

PERK TEST

Perk tests are an evaluation of the absorption rate of the soils (Table 16-3) to adequately dispose of the used water and waste in a system. Although the tests are sometimes carried out differently from location to location, they are all basically the same. It is advisable to check with the local county health department and/or code officials to determine exactly what test is required.

- Begin by digging three holes at different locations within the area proposed as the leach field. Each hole should have a

TABLE 16-3 ABSORPTION RATES OF SOILS

Soil type	*Maximum absorption* Required leach field area/100 gallons of tank capacity	capacity (gallons/sq ft leaching area)
Sand and gravel	20	5
Fine sand	25	4
Sandy loam and clay	40	2.5
Sandy clay	60	1.66
Clay with small amounts of sand and gravel	90	1.11

diameter of at least 6 in. and be at the depth of the proposed drain pipes. Clean and scrape the sides of the holes to remove any fallen dirt.

- Place on the bottom of each hole approximately ½ to ¾ in. crushed stone. Fill each hole with at least 12 in. of water. Maintain the 12-in. depth for at least 4 hours. Keep in mind that the purpose is to try to simulate the actual conditions once the drain field is installed.
- Sometimes when sandy soils are encountered the authorities will forgo the saturation process. Otherwise, the perk tests should be taken within 15 hours and not later than 30 hours.

- Fill each hole with 6 in. of water and measure the amount of absorbing that happens with the level of water in each hole. The purpose of the test is to measure the amount of time it takes 1 in. of water to be absorbed into the soil.
- Divide the time interval used between each measurement in each individual hole to obtain the rate of drop with each of the three holes. A typical figure might be a 1-in. drop per hour.
- Average the results for three test holes to develop the rate of absorption (perk test) for that particular area.

CHAPTER 17
WELLS

Refer to Table 17-1 and Figures 17-1 and 17-2 for general well types and components.

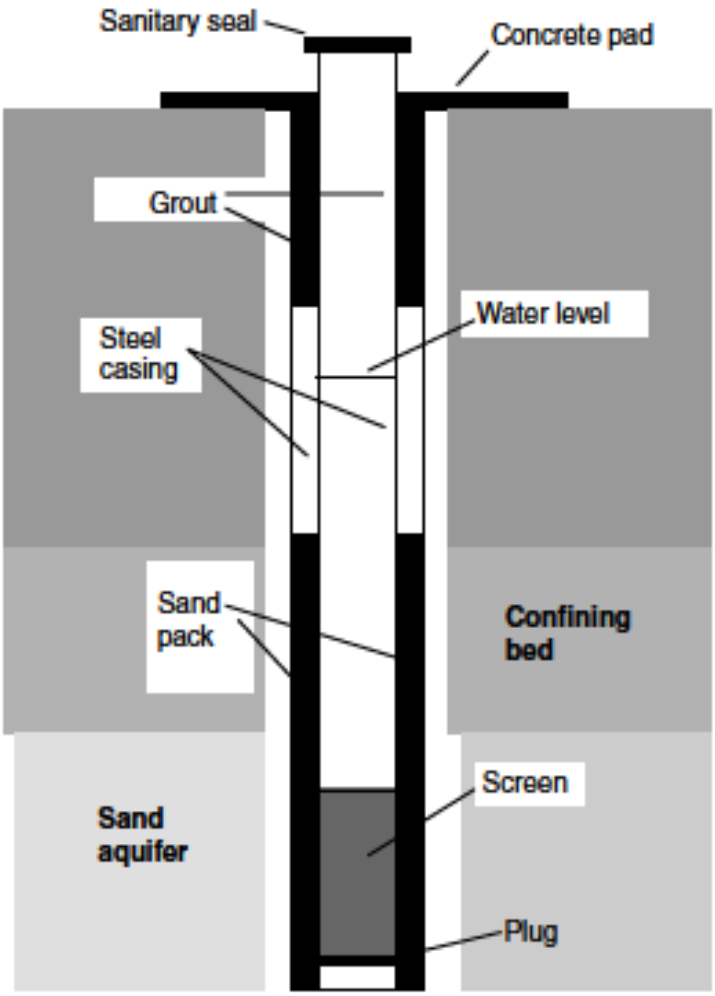


Figure 17-1 TYPICAL WELL

TABLE 17-1 TYPICAL WELL TYPES

Type	Diameter	Maximum depth (ft)	Lining or casing
Dug	3–20 in.	40	Wood, masonry, concrete, or metal
Driven	2–4 in.	50	Pipe
Jetted	3 or 4 in.	200	Pipe
Bored	Up to 36 in.	50	Pipe
Collector	15 ft	130	Reinforced concrete caisson
Drilled	Up to 60 in.	4000	Pipe

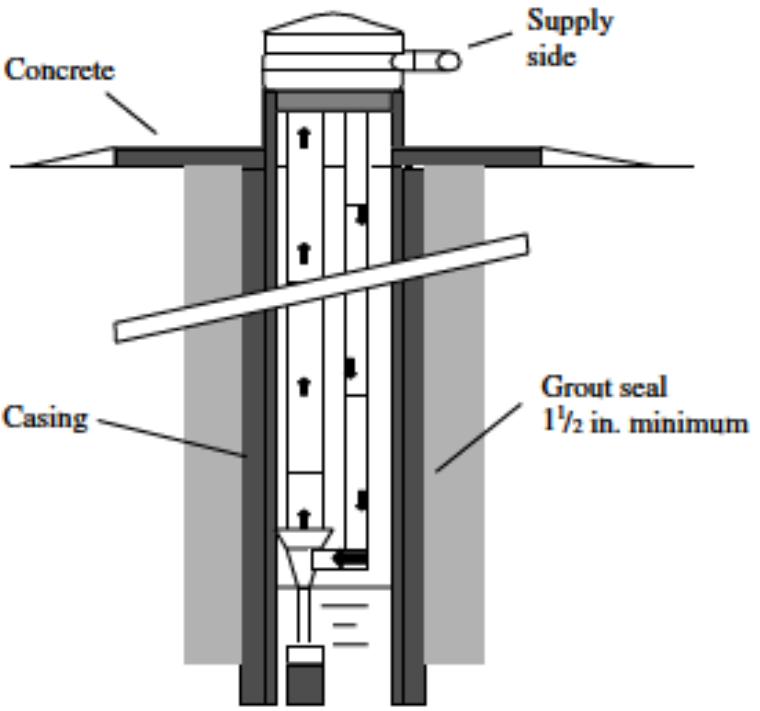


Figure 17-2 TYPICAL DRILLED WELL

PUMPS

Pump specifications are listed in Table 17-2.

TABLE 17-2 WELL PUMPS

Type of pump	Suction lift (ft)	Usual pumping depths (ft)	Pressure heads
Shallow well reciprocating	22–26	22–26	100–200
Deep well reciprocating	22–25	Up to 600	Up to 600
Shallow well single-stage straight centrifugal	20	10–20	100–150
Regenerative vane turbine (single impeller) centrifugal	28	28	100–200
Deep well vertical line turbine (multistage) centrifugal	—	50–300	100–800

DISINFECTING OF WELLS

Every well should be properly disinfected after construction or repair. This can be effectively accomplished by providing a dosage of 50 to 100 ppm available chlorine to the well, pump, pressure tank, and distribution system. After the

well is chlorinated each outlet is allowed to flow until chlorine appears (chlorine is detected by odor or by the orthotoluidine test). The outlet is then turned off and the solution allowed to stand in the system 12 hours and then pumped to waste. Sodium hypochlorite, which is available as household bleach with 5.25% available chlorine, used at the rate of 1 pint per 100 gallons water will do the job.

A typical disinfection procedure is as follows:

- Dilute household bleach with 4 parts water and pour into well to achieve a solution of 50–100 ppm chlorine (1 pint bleach per 100 gallons water).
- Operate pump until solution is in contact with all parts of the water system.
- Let treated water stand in system for 12 hours and then pump to waste.

CHAPTER 18
FIRE PROTECTION SYSTEMS

This chapter covers materials, equipment, and installation procedures for fire protection systems.

FIRE ALARM PLAN

The fire alarm plan should include the following:

- Floor plan
- Locations of alarm-initiating and notification equipment
- Alarm control and trouble signaling equipment
- Annunciation
- Power connection
- Battery calculations
- Conductor type and sizes
- Voltage drop calculations
- Manufacturers, model numbers and listing information for equipment, devices, and materials.
- Details of ceiling height and construction.
- The interface of fire safety control functions.

APPROVALS

- ❑ Review submittal register, and ensure that all material, equipment, and shop drawings are approved prior to the preparatory inspection, and prior to either fabrication or installation. Obtain any helpful manufacturer's installation information.
- ❑ Ensure that seismic restraints (if required) are shown on shop drawings.

STORAGE AND HANDLING

- ❑ Ensure that all materials and equipment are handled carefully to prevent damage.
- ❑ Reject damaged material and equipment. Mark such items and have them removed from the site.
- ❑ Have damaged coatings repaired.
- ❑ In handling heavy pipe use wide belt slings to avoid damage to pipe coatings.
- ❑ Check storage facilities for adequate weather protection, possible damage, and safety hazard.
- ❑ When outside storage is necessary, store materials and equipment aboveground and protected for vehicle traffic.

COORDINATION OF WORK

Continually check for interferences between electrical, mechanical, architectural, and structural features such as cranes, especially in ceiling areas and along walls where the fire protection system is to be installed.

SPRINKLER SYSTEMS

- ❑ Assure that fire protection systems serving occupied buildings are not shut off for repairs without advance notice being given to proper authorities and/or owners.
- ❑ Note valves and equipment proposed for locations within reach of floodwaters.
- ❑ Ensure there are no plans to take water from fire mains for domestic use.
- ❑ Identify painting and coding requirements.
- ❑ Check that sprinkler heads are not painted or blocked in any way.
- ❑ Identify to client areas that have a high likelihood of being used as unauthorized storage and thus blocking sprinkler coverage.
- ❑ Coordinate fire department hose connections to ensure compatibility with the local fire department.
- ❑ Inspect pipe, fittings, and valves. Pipe is to be reamed free from all burrs and fins.

Water Supply

- ❑ Evaluate the contractor's plan of work to minimize interruption of water service.
- ❑ Witness all flow tests and maintain a copy for your records.
- ❑ Ensure that the water line is located below the frost line and meets code in the area.
- ❑ Block off ends of supply lines terminating in the building or valve house.
- ❑ Be certain that pipe joints are left exposed and uninsulated until final inspection and tests are made.
- ❑ See that turns in supply line are braced, blocked, or clamped.

Aboveground Piping

- ❑ Verify size of pipe. Check to ensure all hangers are tight.
- ❑ Make sure pipes run parallel to building lines, with slope to drain.
- ❑ Ensure that branch piping is off top of main.
- ❑ Check slope of system. Where it is impossible to obtain an even slope, plugs should be provided at low points so that the entire system may be drained.
- ❑ Check for inspection test connections required by the NFPA and local jurisdiction.

- ❑ Check that no cutting or notching of structural members for support or passage of pipe is allowed.
- ❑ Ensure that holes through fire walls are provided with sleeves and plates and are properly resealed with approved fire-retardant sealer. Sleeves should be provided where pipe passes through walls and floors.
- ❑ Check that seismic restraints are installed (if required) as approved.

Sprinkler Heads

- ❑ Be sure that heads in accordance with NFPA 13 are installed in the upright position with recommended clearances to roof or ceiling surfaces.
- ❑ For heads in a pendant position, ensure return bends will be used if water is subject to sedimentation.
- ❑ For heads subject to mechanical injury, ensure heads will be provided with approved guards.
- ❑ Make sure that all heads are new and not painted.
- ❑ Determine sprinkler head temperature ratings as proper for ambient temperatures anticipated in the area (e.g., near heaters or skylights, in compressor rooms).

- ❏ Notify the project manager in instances where sprinkler head temperature ratings appear to be inconsistent with anticipated ambient temperatures.
- ❏ Check that spare heads are provided and arrangements made to transfer them to the client at closeout.
- ❏ Where sprinkler heads are shown to be installed in special hazard areas, such as computer shops, confirm that installation will be in conformance with area usage.

Drains

- ❏ See that valves or plugs are provided to ensure drainage of the entire system.
- ❏ Assure that dischargers from all drain valves are visible. They should be arranged so that the wide-open valve position under normal pressure will not cause any damage to surrounding features.

Wet Pipe Systems

- ❏ Check that piping layout is in accordance with approved drawings.
- ❏ Ensure alarm check-valve assembly conforms with connection diagram.

- ❑ Observe installation of water flow indicators for conformance with connection diagram.
- ❑ Confirm insulation and painting and labeling requirements.
- ❑ Check water flow alarm signal.

Dry Pipe Systems

- ❑ Determine that piping layout is in strict accordance with approved drawings.
- ❑ Note dry pipe valve installation for conformance with connection diagram.
- ❑ Inspect installation of air compressors. The air supply line should include a flexible connection and orifice plate. Check motor controller operation. If compressor is equipped with an air storage tank, assure that a condensate water drain is provided at the bottom of the tank.
- ❑ Examine locations and operation of condensate chambers (i.e., drum drips).
- ❑ Check water flow alarm signal time and dry valve trip test time. Be present to witness the test.
- ❑ Where dry pipe valve accelerators are provided, check for proper operation.

Sterilization

Witness dosage, distribution, retention, and final flush-out. Request a copy of the laboratory inspection report if required.

Alarm Facilities

- ❑ Check installations to ensure that all alarm devices have been provided and are in operating condition.
- ❑ Be sure that electric power for alarm signals is taken from the house current supply line ahead of the main switch.
- ❑ Examine alarm system for tie-in with the local fire department. Request a visit by the local fire marshal.
- ❑ Check alarm to ensure that it works as intended with no defects.

Testing

Review test procedure and witness all tests.

THINK SAFETY AT ALL TIMES

CHAPTER 19
UNDERGROUND PIPE SYSTEMS

GENERAL

This chapter covers excavation, trenching, backfilling, and laying of underground pipe systems. The types of underground pipe systems are as follows:

- Water
- Storm drainage
- Sanitary
- Fuel
- Steam, high- and low-temperature hot water

Plans, Specifications, and Layout

Prior to the start of field construction, the plans and specifications should be thoroughly reviewed. The inspector must check and review isolation of any utility lines that are to be worked on. Also, check and review the permanent disconnection and capping of critical utility lines, such as natural gas, fuel oil, or LPG, that are to be abandoned.

Make sure contractor purges all fuel lines before they are abandoned.

- ❏ Observe existing utilities and all possible interference with existing systems.
- ❏ Confer with local utility companies to ascertain that all utilities are indicated on the contract drawings. Utilities not shown on contract drawings should be entered on record drawings.
- ❏ Check all electrical facilities, both aerial and underground.

Accessibility of Valves, Hydrants, and Manholes

All valves, hydrants, and manholes should be constructed in such manner that they can be utilized in the future. Hydrants should be accessible for operation.

Lines and Grades

Lines and grades should be established and staked, and reference bench marks should be set before any excavation or pipe-laying operations.

- ❏ Check each type of utility being installed within a project for conflict as to the layout and elevations at each point of crossing.
- ❏ Check for conflict with existing utilities.
- ❏ Review codes for possible conflicts with specifications and plans.

Connections to Existing Utilities

Plan and coordinate connections to existing utilities. Under no conditions should an existing utility service be interrupted without full coordination with the owners and utility company involved.

Interference

Hold traffic interference to a minimum when installing utilities in or under walks, streets, or railroads. The contractor should ensure that jacking and boring of pipe, where required by the contract, is carried out in a manner so as not to disrupt traffic or other activities.

- ❏ Determine that materials are on hand and that work is organized, so that interference will be held to a minimum.
- ❏ Ensure that warning signs, barricades, and obstruction lights are placed and that regular traffic flows smoothly.
- ❏ Traffic interruptions and detours must be coordinated with the proper road departments responsible for the service.

Damages

See that completed pipe installations are not damaged by movement of construction equipment over or near pipe.

Testing

Pressure tests must be performed prior to backfilling for visual inspection of joints. Alignment tests on all pipes and drain lines are to be made before backfill is completed.

- ❏ Inspect every joint.
- ❏ Assure that corrective action is in accordance with requirements.
- ❏ Record test results.

PIPES AND FITTINGS

Material Compliance

- ❏ Determine the quality of all material delivered to the work site for specification compliance. Pipe, pipe fittings, valves and other components should be checked to ensure that they carry the appropriate stamp and standards organization designations such as ASTM or ASME.
- ❏ Compare submittals with material brought to the job. Check labeling for type, grade, strength, and classification, and determine size and condition of materials. Also check pipe fittings, such as tees, ells, and couplings.

- ❑ Verify the quality of miscellaneous items: valves, service boxes, stops, special connections, tapped tees, etc.

Handling and Storage

- ❑ See that pipes and fittings are handled with the proper tools and equipment. Do not permit dragging and handling of pipe with chains, wire ropes, etc.
- ❑ Check for damaged pipes, fittings, and pipe coating. Reject all damaged materials promptly, and have rejected materials removed from the job site immediately.
- ❑ Make sure an adequate and accessible storage area has been provided.
- ❑ Determine requirements for repairing damaged surface coatings.

Field Coating

- ❑ Check the availability of an approved coating test device.
- ❑ Check for breaks and abrasions of pipe coating.
- ❑ Implement requirements for cleaning of surfaces before coating.
- ❑ Follow the requirement for painting with primer and sealer.

- ❏ Check for the requirement to coat edges or ends of pipe and bolt threads.

LAYING PIPES—GENERAL

- ❏ Check the gradient, line, and grade of the pipeline trench or bed before laying proceeds and after completion of each section.
- ❏ Observe method of jointing permitted.
- ❏ Consult the pipe manufacturer's installation information. Where there is a difference between this information and the contract specifications, this difference should be called to the attention of the project manager.
- ❏ Check for cleanliness of pipe (especially joints) during placement. Cover pipe openings with temporary protection.
- ❏ Ensure that all pipe to be placed on earth is placed on dry, firm soil.
- ❏ Check that plastic pipe is snaked in trenches to allow for expansion and contraction. Refer to Figure 19-1 and Table 19-1.
- ❏ Check for obstructions in pipe, such as pipe plugs or debris.
- ❏ Do not allow for pipes to be left open overnight.

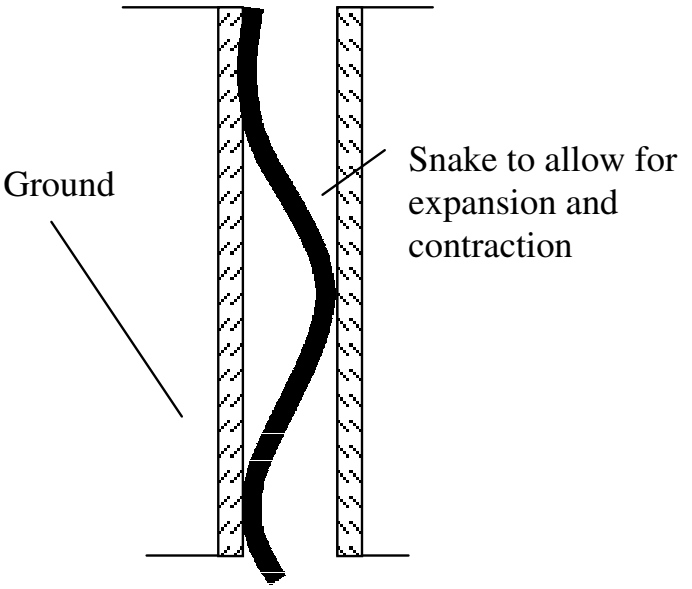


Figure 19-1 LAYING PLASTIC PIPE IN UTILITY TRENCHES

WATER LINES

- ❏ Make sure lines are graded to avoid high points as much as possible. Where high points occur, check specifications for requirements for vacuum and relief valves.
- ❏ See that fire hydrants are plumb with the pumper nozzle facing the roadway. Check location of hydrant shutoff valve and post indicator valve. No shutoff valve is allowed between the post indicator valve and the building it serves.
- ❏ Measure height of the lowest nozzle above finish grade. An 18-in. clearance is usually standard.

TABLE 19-1 EXPANSION CHARACTERISTICS OF PVC PIPING

Temperature change (°F)	Length change of PVC conduit (in./100 ft)
5	0.2
10	0.4
15	0.6
20	0.8
25	1.0
30	1.2
35	1.4
40	1.6
45	1.8
50	2.0
55	2.2
60	2.4
65	2.6
70	2.8
75	3.0
80	3.2
85	3.4
90	3.6
95	3.8
100	4.1

- ❏ Check that fire hydrant threads conform and fit the hose or fire fighting equipment which will be connected to them.
- ❏ Observe the hydrant barrel drain.
  (a) Plug the drain in locations of high groundwater where the hydrant is specified to have no drain. Check hydrant valves to see if they are required to sit on a 4-in.-thick concrete pad.
  (b) In areas where the groundwater is low, the drain plug must be removed and drainage aggregate (18 in. of crushed stone) provided.
- ❏ Require the hydrostatic pressure test and specified leakage tests.
- ❏ Ensure that the contractor sterilizes all phases of water lines that the construction work may have contaminated, not just the new piping runs.
  (a) Main lines require thorough flushing with water until all mud and debris have been removed.
  (b) Disinfecting agent should be added as required and in the recommended quantities. Check local requirements.
  (c) The solution must remain in the line at least 8 and preferably 24 hours.
  (d) There should be no less than 10 ppm residual disinfectant at the extreme end

of the line at the end of the contact period.

(e) The entire system must be flushed thoroughly.

(f) Specifications should require an independent test.

❏ Ensure that valves are accessible. Check the valve nut after backfilling is completed.

❏ Check distance requirements between parallel and crossing water and waste piping.

Hydrant Spacing

Refer to Table 19-2 for siting fire hydrants.

- Hydrant spacing should be reduced by 100 ft for dead-end streets or roads.
- Where streets are provided with median dividers which can be crossed by firefighters pulling hose lines, or where arterial streets are provided with four or more traffic lanes and have a traffic count of more than 30,000 vehicles per day, hydrant spacing should average 500 ft on each side of the street and be arranged on an alternating basis up to a fire-flow requirement of 7000 gallons per minute and 400 ft for higher fire-flow requirements.

TABLE 19-2 NUMBER AND DISTRIBUTION OF FIRE HYDRANTS

Fire flow requirement (gpm)	Minimum number of hydrants	Average spacing between hydrants (ft)	Maximum distance from any point on street or road frontage to a hydrant (ft)
1,750 or less	1	500	250
2,000–2,250	2	450	225
2,500	3	450	225
3,000	3	400	225
3,500–4,000	4	350	210
4,500–5,000	5	300	180
5,500	6	300	180
6,000	6	250	150
6,500–7,000	7	250	150
7,500 or more	8 or more	200	120

- If new water mains are extended along streets where hydrants are not needed for protection of structures or similar fire problems, fire hydrants should be provided at spacings not to exceed 1000 ft to provide for transportation hazards.
- The maximum distance from any point on the road frontage to a hydrant should be reduced by 50 ft for dead-end streets or roads.

- One hydrant should be allowed for each 1000 gallons per minute or fraction thereof.

Thrust Blocking

Thrust blocking should be inspected for proper placement and area of bearing. Refer to Figure 19-2 and Table 19-3.

- ❑ Check thrust blocking and/or tie rods.
- ❑ Check for movement at joints, bands, dead ends, and hydrants.
- ❑ Check wedging at all fittings.

TABLE 19-3 THRUST BLOCK AREA OF BEARING

Pipe size (in.)	*Square feet of bearing*			
	¼ bend	⅛ bend	1/16 bend	Tees, caps, plugs
6 or less	6	3	2	4
8	10	5	3	7
10	15	8	4	11
12	21	11	6	15
14	28	15	8	20
16	36	19	10	25
18	44	24	13	32
20	53	29	15	38
24	75	41	21	53

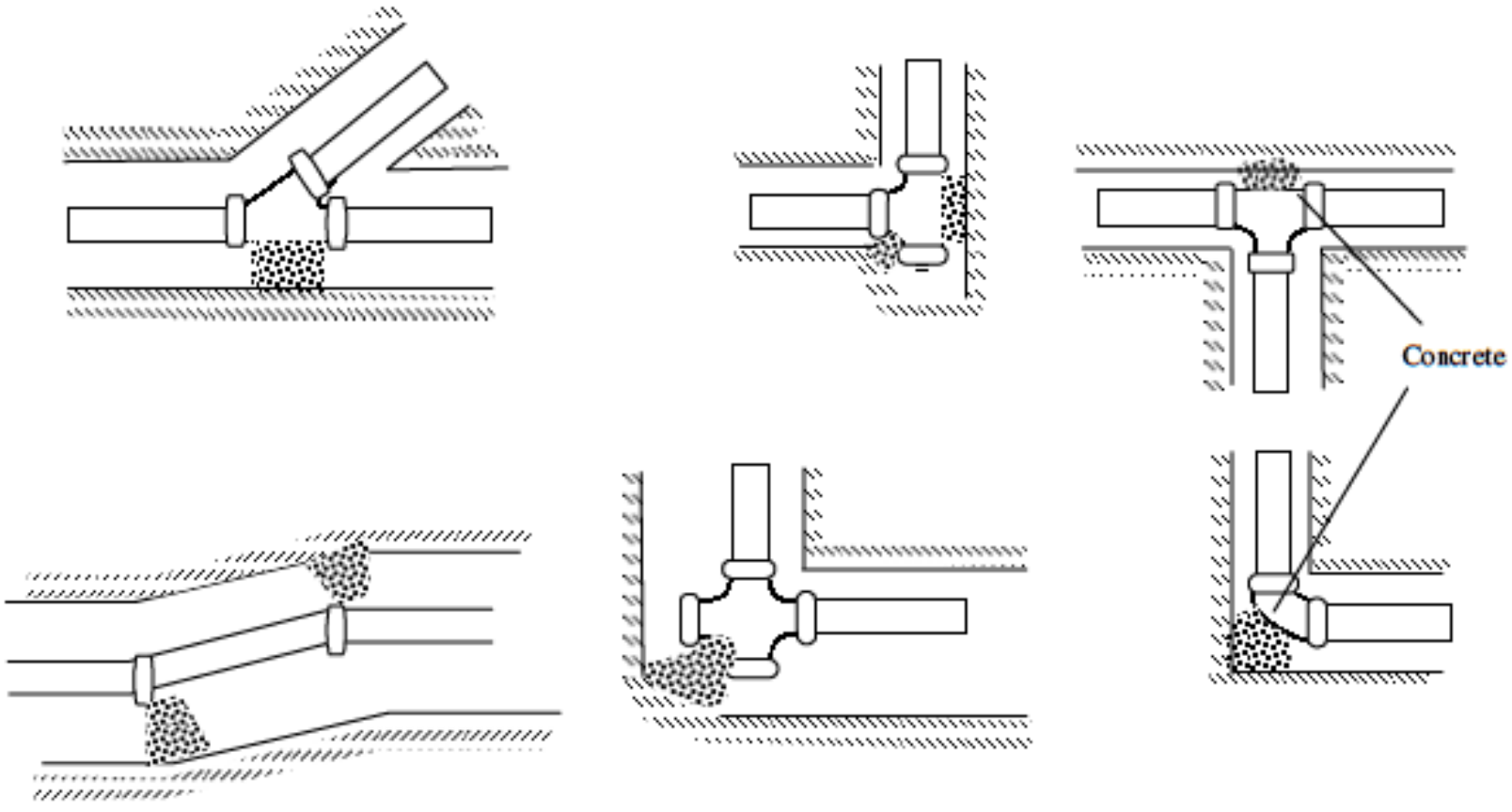


Figure 19-2 TYPICAL THRUST BLOCKING SUPPORTS

FUEL-GAS LINES

- ❏ Do not permit lines to be buried under buildings, nor in trenches with other utilities, unless approved.
- ❏ Enforce safety regulations rigidly during construction of gas and all other fuel lines.
- ❏ Continuously check the area with a detector for an explosive atmosphere. Record all readings!
- ❏ When there is indication of an explosive condition, do not commence work until the explosive condition has been identified and cleared.
- ❏ Install gas pipes above other utilities which they cross, and with a minimum cover of 2 ft. Pipe under pavements or heavily traveled areas must be encased or located deep enough so that there will be no damage from heavy traffic. Verify local codes!
- ❏ Check cleanliness of pipe before lowering into trench.
- ❏ Check pipe coating for damage during connection, laying, and backfilling operations. Permit coated piping to be handled only by hand or with nonmetallic flexible slings.
- ❏ Keep pipe clean during installation by careful handling and by keeping ends of pipe closed.

- ❑ Make sure contractor uses the correct marking tape over the pipe and at the prescribed depth.

FUEL LINES

Fuel lines in this section pertain to underground liquid petroleum systems.

- ❑ Check drain connections at low points and air releases at high points.
- ❑ Check that field application of covering on joints is not done until the pneumatic pressure test has been conducted.
- ❑ Check if screens and filter elements are installed. Check mesh and material; check installation for proper direction of flow; and check clearances for removal of screen and access to drain connection.
- ❑ Check with an approved instrument for fuel vapors that may accumulate in pits or enclosed areas and that can cause explosions.
  - (a) Provide adequate ventilation during operation in a liquid fuel area.
  - (b) Prohibit open fires, sparks, or static electricity in the vicinity of vapors which may be explosive.
  - (c) Check by use of a detector for explosive atmosphere.

SANITARY SEWERS

- ❑ Check layout of sanitary sewer system. Check distance separating sewers from water line. Always install sewer or force main below water lines if the lines are within 65 ft horizontally, unless special provisions are taken at crossings; otherwise spacing must be at least 5 ft horizontally. Check for special code requirements where sewer lines or force mains cross above water lines. Require leakage tests for sanitary sewers and force mains. Check to see that spigot end of the pipe is pointed downstream in the pipeline.
- ❑ Check that the designed grade is maintained between manholes.
- ❑ Assure that the top elevation of the manhole is flush with paving grades or higher than finished grade of ground surrounding area, as specified.
- ❑ Check that the contractor is following specific safety precautions to be taken when working in sewers. Sewer gas is extremely dangerous. Review the contractor's safety plan.

STORM SEWERS

- ❑ Check that installation is performed by proceeding up grade, verifying that spigot or tongue end of pipes point in the direction of flow.
- ❑ Check the installation of all fittings, joints, connections at manholes, and connections to existing facilities.
- ❑ Check grade, elevation, and finish of paved inverts.
- ❑ Check that elliptical pipe sections are handled carefully in transporting, storing, and installing.
- ❑ Check for installation of all subdrainage tile as shown on plans.
- ❑ Where watertight joints are required, see that hydrostatic test requirements are met, and that rubber gaskets are not affixed more than 24 hours prior to pipe installation and are protected from sun, dust, and other deleterious agents.
- ❑ Cover openings to prevent the entrance of dirt, debris, or animals into the pipe.
- ❑ Require shaping of the trench bottom as detailed in either the plans or shop drawings.
- ❑ In rocky soils, overexcavate at least two pipe diameters and fill with suitable backfill material before placing pipe.

HEAT DISTRIBUTION LINES

- ❑ Check that all lines are straight, both vertically and horizontally. All heat distribution piping is subject to expansion and contraction. Expansion of piping will be absorbed by expansion joints or fabricated pipe loops. There must be room for the pipe loop to move as well as for maintenance.
- ❑ Verify strength, security, and proper placement of anchors and supports.
- ❑ Inspect rigid installation of anchors.
- ❑ Require uniform pitch of steam pipes. *Trap all low points.*
- ❑ Ensure that the manufacturer's recommended installation procedure for the insulation materials has been followed, unless there are specific changes on the approved shop drawings. Log and report all discrepancies to the project manager.
- ❑ Store and protect insulation from the weather.
- ❑ Keep the underground pipe conduit system dry during and after construction.
- ❑ Examine waterproofing carefully. Check shop drawing details for both field-applied and factory-applied waterproofing to protect the insulation.

- ❏ Ensure that valve pits are watertight and have sumps or drains. Check for proper valves, fittings, supports, seals around pit openings, casing, drain, vents, sump, aluminum jacketing over insulation, ladder, etc.
- ❏ Also check valve pits to ensure that they are of the required size and that valves, flanges, and other components have been located as to be accessible and to provide sufficient space for ease of maintenance. Check for requirements for future work?
- ❏ Check welding of pipelines for compliance with specification requirements and the applicable codes.
- ❏ Ensure that all changes in direction are done with approved type fittings.
- ❏ Check welds or metal casings on underground steam lines for leaks or damaged asphalt coatings.
- ❏ See that the proper class of underground system materials have been tested for acceptability.
- ❏ Require that all low points in the system are drained and high points are vented.
- ❏ Assure that the field testing is satisfactorily performed, including hydrostatic, visual, and holiday detector tests. Record test results.
- ❏ Check for drainage of groundwater from system.

JOINTING OF PIPES UNDERGROUND

- ❑ Check to see that all jointing surfaces are kept clean.
- ❑ Check to ensure that pipes of different materials, densities, or manufacturers can and are being properly joined. For example, heat fusion of plastic pipe of different densities is problematic. This piping should be joined with mechanical couplings to ensure a leak-proof connection. Also be aware of the need for cathodic protection for metal piping of different materials.
- ❑ Ensure that pipes are not joined in mud and water.
- ❑ Check tightness of joints.

Hot-Pour Joints

Hot-pour joints must be clean and dry. The presence of moisture may cause explosion and possible injury.

- ❑ Check for uniformity of annular space.
- ❑ Check method of application and make sure all joints are adequately filled.
- ❑ Check temperature of the compound.

Poured Lead Joints

- ❑ Check packing for uniformity and tightness.
- ❑ Check depth and amount of lead being placed in joints.
- ❑ Check the pouring operation. It should be done in one continuous pour.
- ❑ Check driving during caulking. If lead is permitted to be displaced to a depth greater than ¼ in., the joint should be remade.

Flexible Joints

- ❑ Check for approved material, make, type, and number of splices.
- ❑ Check placing and positioning of flexible gasket.
- ❑ Check depth of gasket with a gauge.
- ❑ Check use of approved lubricant.
- ❑ Conduct a hydrostatic test as soon as possible. Do not cover flexible joints until the test is done.

Tapered End Couplings

Drive tapered end couplings up tight when joining bituminous fiber pipe.

Cement Mortar Joints

- ❑ Determine specific requirements for types of joints (oakum, diaper band, etc.).

- ❏ Ensure that mortar meets the requirements of the contract specifications.
- ❏ Observe that the jointing operation will completely fill joints and form a bond on the outside.
- ❏ Make sure cement mortar joints are cured.
- ❏ Ensure excess grout is removed from inside and outside of pipe.
- ❏ Ensure that joints are protected from weather conditions until fully cured.

Pipe Threads

- ❏ Cut pipe threads with the appropriate tools.
- ❏ Ensure proper length threads. The pipe taper is lost by overlength threading.
- ❏ Ream pipe flush on the inside surface.
- ❏ Apply joint compound to the threads on the pipe, not to the fittings.
- ❏ Make up all joints tightly.

Copper Tubing Joints

- ❏ Check types of pipes and fittings used against types required.
- ❏ Make sure copper tubing is cut square and burrs removed.
- ❏ Ensure clean tubing before fluxing and soldering. Check for correct lead content (0.2% maximum).

- ❑ Check type of tools used for flaring compression type joints.

Welded Joints

- ❑ Inspect contractor's qualifications and approved procedure.
- ❑ Ensure that as much fabrication and welding as possible is done before lowering pipe into trench.
- ❑ Check against possible cave-in when in trench.
- ❑ Explore for explosive gases within pipes and before welding in fueling areas.
- ❑ Check pipe ends for bevel.
- ❑ Make a very careful inspection of welds in hard-to-reach areas.
- ❑ Remove all welding slag before visual inspection of joints.
- ❑ Do not cover joints until all testing has been satisfactory completed.

Mechanical Joints in Manholes

Install mechanical joints in manholes in accordance with manufacturer's instructions.

Flanged Joints in Manholes

Install gaskets and bolts and assure that flanges are not damaged. Use proper bolt torquing procedures.

Corrugated Banding

- ❑ Check for proper overlap. Laps of all circumferential joints in the pipe should provide that the outside lap be on the downstream side of the joint with the longitudinal laps on the side of the in-place pipe.
- ❑ Ensure all markings indicating the top of the pipe coincide with the specified alignment of the pipe.
- ❑ While the connecting band is being placed, assure that the band is adjusted correctly.
- ❑ Check the specifications, or necessity, to use bituminous material at the joint after jointing.

Caps or Plugs

- ❑ Make sure open ends of pipes are closed when work is not in progress and always at the end of each work day.
- ❑ Keep pipelines clean of all debris, rodents, or water.

MANHOLES AND CONCRETE ENCASEMENTS

- ❑ Check material requirements with delivered materials at the preparatory inspection.
- ❑ Check dimensions and layout.

- ❑ Check invert elevations and details of the invert channels in manholes.
- ❑ Check placement of material such as concrete, reinforcement, brick, block, plaster, frames and covers, and rungs.
- ❑ See that manholes are not obstructed by dumped waste concrete or other construction material.
- ❑ Provide protection from construction activities.

EXCAVATION AND BACKFILLING

Excavation

Existing underground utilities will be carefully marked by the appropriate utility company before excavation. Keep them protected for the duration of the work. Existing utilities will be suitably supported to prevent damage to them and to prevent transferring any direct load onto the new piping system below.

- ❑ Check need for shoring or excavation to required side slope as per OSHA requirements (see Chapter 20).
- ❑ Report all damaged existing utilities immediately.
- ❑ Note location of all unknown or unreported utilities for inclusion on revised utility plan.
- ❑ Determine that access steps or ladders are

provided in trenches, where necessary, and that they are maintained in safe condition. Check that all OSHA guidelines are strictly followed.

Trenching

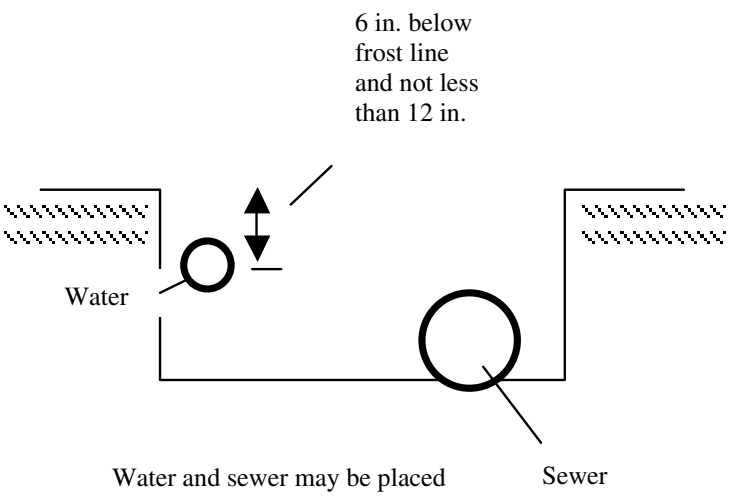
- ❏ Begin trench excavation for sewers at the lower end of the line and proceed up grade to protect the work from possible flooding, unless job conditions prohibit.
- ❏ Check specifications and job requirements for maximum width of trench and minimum depth of pipe.
- ❏ Check bed of trench for grade and suitability of materials before any pipe is laid. If the trench is overexcavated, the bed should be brought to grade and compacted. When encountering rock excavations, check the minimum overdepth specified and check that backfilling is performed with select bedding material.
- ❏ Keep water from the trenches during construction. Use pumps or a well point system.
- ❏ Check that final hand grading precedes pipe laying by no more than the amount of pipe that can be installed the same day.
- ❏ Check excavation of the bottom of the trench. Make sure it is graded and shaped to the bot-

tom quadrant of the sewer pipe. Verify that excavation under all bells has been performed as specified. Ensure approved gravel bedding material has been used.

- ❑ Inspect distance between potable water lines and sanitary sewer trenches for minimum allowable clearance. See Figure 19-3.
- ❑ Check pipe-handling procedures and do not allow loads to be swung over the heads of workmen.
- ❑ Check thrust blocks. Verify that they are in the correct locations. Record all approved deviations from plans and specifications.

Backfilling

- ❑ Ensure that special care is taken when backfilling around ductile iron. Recheck alignment after backfill operations.
- ❑ Require leakage tests for sanitary sewers. Verify that specific backfill and compaction requirements for plastic pipe have been followed.
- ❑ Permit placement of backfill only between pipe joint locations until all lines have been tested and/or approved, unless job conditions require otherwise. In the case of pressure testing, place sufficient backfill material to prevent pipes from moving out of place.



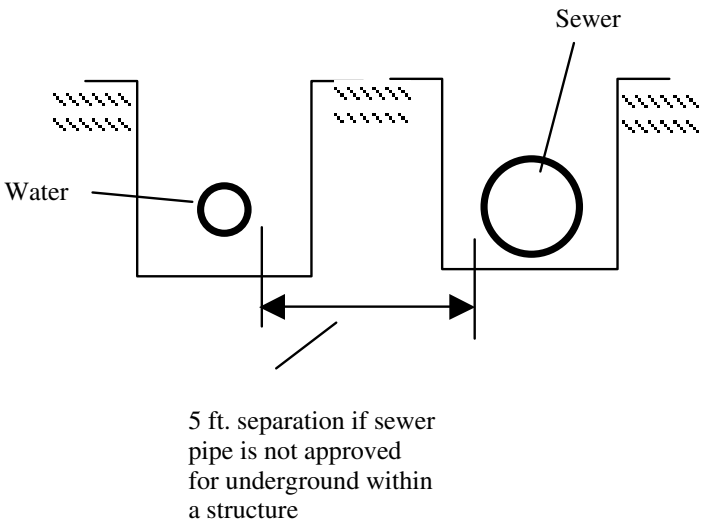


Figure 19-3 WATER AND BUILDING SEWER LINES IN TRENCHES

In the case of wrapped and coated piping, do not permit any backfilling until the coating at welds and fittings has been completed and the entire coating tested for holidays. Assure that backfill in contact with the piping does not damage protective coatings. Make sure that all lines are located on as-built drawings before backfilling.

- ❏ Check backfill material. Inspect the placement operation for uniform layers (6–8 in.) on each side of the pipeline.
- ❏ Check that the contractor keeps foreign materials and large stones out of the backfill material.
- ❏ Conduct a backfill operation check:
  - (a) Test the thickness of each layer for moisture content and compaction.
  - (b) Do not machine-compact fill on top of a pipeline until the required minimum cover has been placed.
  - (c) Ensure that there are no large or sharp rocks used.
  - (d) Have the contractor check the soil density as required.
  - (e) Check sewer lines to manhole after the backfilling operation. Check from manhole for broken pipe, settlement in the line, lateral movement, and cleanliness.

- ❏ Review and study all plans and specifications—not just the plumbing set.
- ❏ Inspect incoming materials against approved shop drawings.
- ❏ Inspect for proper storage of materials.
- ❏ Check all certifications and licenses of on-site workers.
- ❏ Observe contractor in pipe-cutting operations for each type of piping.
- ❏ Observe contractor in welding operations.
- ❏ Review contractor's safety plan when applicable.
- ❏ Do not allow structural components to be cut, notched, stressed, or altered in any way without documented design approval.
- ❏ Do not allow installation of damaged or dirty materials.
- ❏ Inspect all installed equipment for protection against damage during construction.
- ❏ Ensure that all ADA (Americans with Disabilities Act) clearance requirements have been met.
- ❏ Ensure that all equipment has been thoroughly cleaned before turnover.
- ❏ Inspect and review the Operation and Maintenance Manuals at project turnover.
- ❏ Enforce all project, OSHA, State, and safety standards.
- ❏ Review all Change Orders and verify that Record Set Drawings are being maintained.
- ❏ Make safety your first priority at all times.

NOTES